

THE INTEGRATED STEAM APPROACH IN PRESCHOOL EDUCATION: A PROJECT-BASED PEDAGOGICAL PRACTICE “THE SUN, THE EARTH, THE MOON, THE STARS”

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Abstract: This paper presents and analyses a project-based pedagogical practice for integrating the STEAM approach in preschool education through the thematic project “The Sun, the Earth, the Moon, the Stars”, implemented with children aged six to seven in a Bulgarian kindergarten. The aim is to identify and systematise methodologically the affordances of a problem-based and project-based STEAM environment for stimulating the cognitive, inquiry, constructive, technological, communicative and creative activity of children. The study pursues five objectives: to outline the theoretical basis of early integration of science, technology, engineering and mathematics with the arts; to present the logic of the thematic project and the role of the problem situation; to analyse the manifestations of the forms of activity listed above; to derive an applied model for organising such activities; and to state the limitations of the analysis together with directions for subsequent empirical research. The methodology is qualitative and descriptive, combining pedagogical observation with analysis of the products of children’s activity, namely drawings, models and constructed rockets, across a ten-day project cycle structured around problem situations, discussion, modelling, construction and reflection. The practice began with an authentic question raised by a child and proceeded through the exploration of cosmic phenomena, work with encyclopaedias and multimedia resources, algorithmic tasks with an educational floor robot, the engineering design and construction of rockets from diverse materials, artistic depiction and team presentation. The activity was organised in four consecutive stages – the emergence of the problem, the purposeful search for information, construction, and presentation – and the families of the children were involved as partners who supplied materials for the constructions. The observations indicate sustained cognitive and emotional engagement, a shift from spontaneous questions towards purposeful information seeking, planning, testing and revision of solutions, as well as manifestations of collaboration and argumentation. On this basis, the applied model “Problem – Exploration – Creation – Presentation” is proposed, in which the problem is the organising centre, while scientific, technological, engineering, artistic and mathematical means are incorporated functionally in order to investigate and solve it. It is concluded that such integration is pedagogically meaningful when it preserves the play-based nature of learning and positions the child as an active researcher, designer and creator. The data are contextual and do not support causal inference or generalisation beyond the setting described; it is therefore recommended that the model be tested on a broader sample, with predefined indicators and combined qualitative and quantitative methods.

Keywords: STEAM; preschool education; project-based learning; inquiry-based learning; educational robotics.

1. INTRODUCTION

Contemporary preschool education faces the need to combine the fundamental value of play with conditions for the early development of curiosity, critical thinking, communication, creativity and the ability to solve problems. In this context the STEAM approach makes it possible for scientific, technological, engineering, artistic and mathematical content to be taught not as isolated areas, but to be incorporated functionally into integral cognitive situations.

For the preschool child, integration becomes meaningful when it arises from a question that can be experienced, investigated and materialised in action. The present study therefore places the emphasis not on the mechanical accumulation of STEAM activities, but on organising them around a problem that generates a need for observation, orientation, programming, construction and sharing.

The thematic project “The Sun, the Earth, the Moon, the Stars” is a suitable environment for such integration, because it combines the natural interest of children in space with opportunities for modelling, spatial relations, causal explanation and creative presentation.

Research in early STEM education emphasises the importance of an enriched environment in which children can explore, ask questions and receive responsive support from an adult (Wan et al., 2021; Yildirim, 2021). McClure et al. (2017) stress the need for STEM experiences to begin early and to be connected with children’s everyday curiosity. Scholars also argue that science education can be present as early as early childhood, provided that it is age-appropriate and grounded in experience and inquiry (Eshach & Fried, 2005).

The transition from STEM to STEAM broadens the integrative logic by including the arts as a means of representation, design, imagination and communication. In the model of Yakman (2008) the disciplinary areas are considered in their interrelation, which supports a holistic organisation of educational experience. A

systematic review of interventions comparing the two approaches indicates that the inclusion of the arts has a positive effect on learners' creativity (Aguilera & Ortiz-Revilla, 2021).

Project-based learning creates conditions for knowledge to be acquired in the process of solving a meaningful task. Instead of merely reproducing factual information, the child takes part in creating a product, tests ideas and works together with other children. A meta-analysis of informal project-based STEM learning confirms the positive effect of this organisation of learning and outlines the conditions under which it is most pronounced (Santhosh et al., 2023). Project-based inquiry has also been planned and implemented successfully in preschool settings (Chen & Tippet, 2022).

The problem situation as an integrator is of particular importance. It allows the separate educational domains to be included not through the formal "addition" of activities, but as different means of resolving a shared cognitive problem.

The framework of the National Research Council (2012) shifts attention from the acquisition of scientific facts alone towards participation in practices: asking questions, developing and using models, planning and carrying out investigations, analysing information, constructing explanations and designing solutions. At preschool age these practices are realised in a simplified, play-based and visual-active form.

Constructive activity is a natural bridge to engineering thinking: the child moves from an idea to a plan, selects materials, creates a model, tests its stability and functionality and presents the result. Construction thus becomes a means of solving a problem.

The aim of the paper is to present, analyse and systematise methodologically the affordances of the integrated STEAM approach in a project-based pedagogical practice on a topic from the educational domain "Construction and Technologies", carried out with children from the fourth age group in kindergarten.

The main objectives are: to outline the theoretical basis of early STEAM integration; to present the logic of the thematic project and the role of the problem situation; to analyse the manifestations of cognitive, inquiry, constructive, technological, communicative and creative activity; to systematise an applied model for organising STEAM activities; to state the limitations of the present analysis and the prospects for subsequent empirical research.

2. MATERIALS AND METHODS

The STEAM practice on the topic "The Sun, the Earth, the Moon, the Stars" was implemented with children from the fourth age group, aged six to seven, in a Bulgarian kindergarten during the 2025 – 2026 school year, within the framework of Ordinance No. 5 on preschool education (Ministry of Education and Science, 2016). The project activity lasted ten days. The final products included a model of the solar system, mock-ups of rockets, astronaut props and drawings.

The design of the study is qualitative and descriptive, and the sources of data were pedagogical observation during the situations of the project and analysis of the products of the children's activity, namely drawings, models and constructed rockets. Problem-based, situational, discussion-based and practical-active methods were applied, using a computer and multimedia, an encyclopaedia and educational films about space, photo albums, a Bee-Bot floor robot, works of art and music, as well as a variety of construction and art materials.

The project was organised as a sequence of interrelated situations in which the children's questions determined the direction of cognitive activity and, instead of receiving ready-made answers, the children observed, made conjectures, sought information, experimented, modelled and constructed. The project was interdisciplinary in character and integrated the educational domains of Construction and Technologies, the Surrounding World, Bulgarian Language and Literature, Mathematics, Fine Arts, Music and Physical Education, while at the same time creating conditions for the development of key twenty-first-century skills: critical and creative thinking, problem solving, initiative and collaboration.

The teacher performed a facilitating function. She provoked with questions, provided materials and a safe environment, supported the formulation of conjectures and directed attention towards observation and comparison, without depriving the child of the opportunity to choose, to make mistakes, to correct them and to argue a case. The application of the STEAM approach in this project activity created conditions for science, technology, constructive (engineering) thinking, the arts and mathematics to meet in a shared space within the children's inquiry (Table 1).

Table 1. STEAM integration in the project

Component	Function in the project	Examples of manifestation
Science	Understanding and investigating natural and cosmic phenomena	observation, comparison, questions, conjectures, modelling of the Earth–Moon–Sun system
Technology	Using a tool to solve a cognitive task	Bee-Bot, sequence of commands, route, testing and correction
Engineering	Designing and creating a material solution	construction of a rocket/model, choice of elements, stability, improvement
Arts	Visualising, experiencing and communicating the scientific	drawing, mock-ups, role-play situations, artistic presentation
Mathematics	Orientation in space, relations and sequences	directions, counting, comparison, distance, order, algorithm

Source: The author's own elaboration, mapping the project's activities onto the STEAM components.

3. RESULTS

The project activity began with the emergence of an authentic cognitive problem and passed through four stages. **First stage.** The project began naturally during the game “Thing-Finders” in the kindergarten yard. One of the children found a stone of unusual shape and reddish colour. The find provoked spontaneous interest and numerous questions: “What is this stone?”, “Where did it come from?”, “Why does it look different?”

Instead of receiving a ready-made answer, the children were encouraged to voice their own conjectures. Through brainstorming, various hypotheses emerged: that the stone might have been brought from another place, that it might be part of a meteorite, or even that it might originate from another celestial body. The chance find thus became a cognitive provocation and the starting point for inquiry.

In order to seek more information, the children visited an astronomical observatory, where they observed celestial bodies and broadened their ideas about the solar system, after which came educational films, work with encyclopaedias, familiarisation with the planets, and artistic and didactic activities.

The accumulated information did not answer the initial question immediately. On the contrary, new questions arose: “How can we find out more about the other planets?”, “How could we reach them?”, “What must an astronaut know and be able to do?” The problem thus led the children naturally into the next stage of the project.

Second stage. During the second stage the children's curiosity was directed towards the purposeful search for information. The children explored the profession of the astronaut: why a person can fly in space, what a spacesuit looks like and how life proceeds in a space environment.

Familiarisation with space exploration was enriched with materials about the flight to the Moon, a literary text and the poem “Astronaut”, as well as with the active game “Astronauts on Board”.

The activities with the programmable Bee-Bot robot occupied an essential place: each child chose a card with the image of a planet to which they had to fly, and planned and programmed the route of the robot. In this way the cognitive content about space was integrated with initial skills of algorithmic thinking, spatial orientation, sequencing and verification of one's own solution. The children also made astronaut props and became familiar with the design of flying vehicles through a multimedia photo album.

The next problem then arose: “The astronauts are ready, but can we fly without a rocket?” The answer directed the children naturally towards a new challenge: “How can we build a rocket ourselves, and what materials will we need?”

Third stage. The third stage turned the knowledge acquired into practical action. After considering various proposals, the children decided to construct rockets from boxes, cartons, bottles and other everyday and recyclable materials. The parents also became involved, providing a variety of materials.

The children divided into three teams, chose names and captains, and distributed the responsibilities among themselves. The teams proposed different constructive solutions: one team created a rocket by combining several boxes, another used a large carton as the basis of the construction, and the third combined various bottles.

The children discussed independently how to join the elements, compared alternatives and changed their decisions when difficulties arose. The constructions were joined, shaped, decorated and coloured, and one of the teams proposed the use of aluminium foil in order to achieve a different design.

This stage transformed the child from a recipient of information into a designer and a creator, and what mattered was less the perfection of the final product than the process of its creation: the children proposed ideas, defended solutions, negotiated, made and corrected mistakes, and experienced success as the result of a shared effort.

Fourth stage. The teacher and the children organised the final day as a special celebration: they arranged an exhibition of the creative products made during the project and invited their parents to view the results.

The culmination was the role play “Space Expedition”, in which the children again worked in three teams. The mission of each team was determined by drawing lots, and the routes were marked visually. The “astronauts”

put on the helmets they had made, took their places in the rockets, and a launch was simulated with sound and light effects.

After the “landing”, the children had to apply the knowledge they had acquired: to determine the position of the planet, to recall its characteristic features, to compare its conditions with those on Earth, and to establish whether the stone found at the beginning of the project bore any visual similarity to the samples under consideration.

Within the play scenario the children arrived at the hypothesis that, because of its reddish colour, the stone might conventionally be associated with Mars. The initial problem thus received a playful and exploratory resolution, without the children’s hypothesis being presented as a scientifically proven fact.

After the return to Earth the children were met by a “journalist” and a “reporter”, roles performed by the teachers. The children answered the journalist’s questions about what they had learned, which activities they had found most interesting, what difficulties they had encountered and how they had worked as a team. This concluding reflection enabled the children not only to demonstrate their knowledge, but also to make sense of their own process of learning.

Observations during the project. The observations made in the course of the project showed a high degree of cognitive and emotional engagement: the children gradually moved from spontaneously asking questions towards more purposeful observation, information seeking, formulation of conjectures and practical testing of possible solutions.

Construction occupied a central place in the project activity, because it allowed the child to transform an idea into a material model. When creating a model of a rocket, the children first examined its structure, distinguished the main parts, discussed their function, selected a suitable construction material and created their own solution, after which they tested the result and improved it. Pedagogically significant is the cycle “conception – action – testing – modification”. When a model was not stable, or did not correspond to the initial idea, a natural need for redesign arose, which turns error into a resource for learning.

The work with the Bee-Bot complemented this line: the child planned a route in advance, encoded a sequence of actions and, where necessary, corrected the algorithm.

The team organisation stimulated communication, mutual assistance and the distribution of roles and responsibilities, and the children gradually came to realise that the shared product is the result not of an individual idea, but of the coordinated efforts of the whole team.

The integration of artistic, musical, motor and technological activities allowed every child to participate according to their own interests and strengths.

A further significant outcome was the involvement of the parents, which turned the family into a partner in the realisation of the project activity.

4. DISCUSSIONS

The observations obtained are consistent with the theoretical positions on early STEM education, according to which children’s learning is supported by an environment for inquiry and by an adult who guides without taking away the initiative (McClure et al., 2017). In the practice under consideration the teacher performed precisely such a facilitating function, a role that reviews identify as demanding in terms of preparation and confidence (Yildirim, 2021).

The project also corresponds to the understanding of the National Research Council (2012) that science and engineering education should involve practices and not only ready-made knowledge: the child does not simply “know” what a rocket or a planet is, but observes, models, plans, constructs and presents.

The observations relating to the Bee-Bot are consistent with evidence that tangible robot programming in the early years supports computational thinking and sequencing ability (Yang et al., 2022), and that children of this age acquire the underlying skills through guided play while still requiring adult support in programming precise routes (Critten et al., 2022; Su & Yang, 2023). The cooperative work around the robot and the constructions likewise corresponds to reports that shared activity with robotic toys supports social and emotional competencies (Kewalramani et al., 2021), and the contribution of the families reflects models of parent-involved early engineering education (Ata-Aktürk & Demircan, 2021).

A significant result of the analysis is the role of the problem situation as an integrator: each of the components set out in Table 1 enters according to its function, in understanding, comparing, planning, constructing and presenting. Integration is thus organised around the problem rather than around the disciplines.

The methodological contribution of the study is the systematisation of a cyclical model for early STEAM integration – not a new general theory of STEAM education, but an applied framework derived from the logic of one specific pedagogical practice.

Table 2. The author's applied model "Problem – Exploration – Creation – Presentation"

Stage	Pedagogical content
Problem	authentic situation, children's wonder, formulation of questions and conjectures
Exploration	observation, comparison, information seeking, experience, modelling and testing
Creation	technological planning, algorithmic action, engineering construction and artistic solution
Presentation	explanation, demonstration, team sharing, argumentation and reflection

Source: The author's own model, derived from the pedagogical practice described in this paper.

A distinctive feature of the model is that it does not begin from a predetermined set of STEAM activities. Its starting point is the child's problem, which becomes the organising centre, while the scientific, technological, engineering, mathematical and artistic means become the instruments for its investigation, solution and presentation.

Limitations. The practice was implemented in one specific educational context, is not based on a representative sample, used no control group and applied no standardised instrument for the quantitative measurement of cognitive activity before and after the intervention. The observations are pedagogical and qualitative, and subjective interpretations are therefore possible.

Consequently, no causal relationship can be claimed between the application of the STEAM approach and an increase in specific indicators. The more accurate conclusion is that the practice creates observable conditions and situations for the manifestation and exercise of cognitive, inquiry, constructive, communicative and creative activity.

5. CONCLUSIONS

The project "The Sun, the Earth, the Moon, the Stars" demonstrates that the STEAM approach can be applied at preschool age through pedagogical practices attuned to the natural way in which the child learns. Its strength lies not only in the appeal of the topic or in the use of technology, but in the organisation of a complete cognitive cycle, in which the child wonders, investigates, creates, presents and makes sense of the result.

The analysis shows that STEAM integration is methodologically most meaningful when it is organised around an authentic problem: the separate domains then cease to be curricular fragments and become interacting means for solving a shared cognitive task.

In this sense the model "Problem – Exploration – Creation – Presentation" may be regarded as a practice-oriented framework for organising STEAM activities in preschool education. Its value lies in turning children's curiosity into an educational activity that is structured while retaining its play-based character.

The most essential pedagogical conclusion is that the child need not be placed in the role of a "little scientist" who reproduces scientific facts. More valuable is the role of the researcher, designer, discoverer and creator, who, through age-appropriate actions, builds a culture of asking questions, seeking evidence, designing solutions and sharing ideas.

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