PEDAGOGICAL FOUNDATIONS OF THE INNOVATIVE STEAM APPROACH IN EARLY CHILDHOOD EDUCATION

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Abstract: *STEAM education in early childhood represents a paradigm shift that goes beyond the traditional transmission of knowledge, directing the educational process toward the integrated development of the child as an active agent of their own learning. This article examines the pedagogical foundations of the STEAM approach in preschool education and highlights the way in which they can become a catalyst for the professional development of future early childhood educators. Grounded in socio-constructivism (Vygotsky), experiential learning (Kolb), and project-based pedagogy (Kilpatrick), STEAM education emerges as a transdisciplinary learning framework that fosters exploration, investigation, and guided reflection. The second part of the article emphasizes the role of students' active participation in STEAM-based projects and workshops as a strategy for developing 21st-century pedagogical competences critical thinking, creativity, adaptability, intelligent use of technology, and inclusive pedagogical practices. Through examples from a university workshop, the article illustrates how initial teacher training can evolve into a reflective and application-oriented process in which the student transitions from the role of passive recipient to that of designer of educational experiences. The conclusions suggest that STEAM education has the potential to shape a new professional profile of the educator innovative, reflective, and capable of mediating complex learning within a constantly changing world.*

Keywords: *STEAM approach; initial teacher education; students; pedagogical competences; teaching practice; educational innovation.*

Theoretical Foundations of STEAM Education

STEAM Education (Science, Technology, Engineering, Arts and Mathematics) in early childhood is not merely a curricular innovation, but a profound pedagogical paradigm shift. It stems from a holistic understanding of the preschool child as an active, creative learner capable of constructing knowledge through social interaction, practical exploration, and integrated experiences. The pedagogical foundations of STEAM in both private and public preschools in Romania are aligned with classical learning theories as well as with recent research on cognitive and socio-emotional development.

One of the core foundations of STEAM education is constructivism (Piaget) and its socio-constructivist extension (Vygotsky), which emphasize that learning at an early age is the result of the child's active interaction with both the environment and others. In the STEAM context, hands-on activities and collaborative projects enable children to develop scientific and mathematical concepts through discovery, to strengthen problem-solving abilities, and to construct understanding through dialogue and social negotiation. The zone of proximal development (Vygotsky,1978) is essential, with the educator acting as a facilitator who provides adaptive scaffolding to support each child's cognitive and emotional progress.

Inspired by Dewey and Kolb, STEAM education promotes experiential learning, in which knowledge is derived from action, reflection, and practical application. STEAM learning experiences typically follow a cyclical process observing, hypothesizing, experimenting, discussing results, and applying innovative solutions. Project-based pedagogy (Kilpatrick) extends this process by engaging children in integrated activities that combine science, technology, the arts, and mathematics, enabling the development of interdisciplinary competencies within an authentic and motivating educational context.

Play represents the central medium of learning in early childhood. In STEAM-based contexts, play becomes guided exploration (Weisberg et al., 2016), through which children encounter complex concepts in a playful setting supported by strategic questioning and engaging materials. This approach merges creative freedom with pedagogical intentionality, fostering executive functions, critical thinking, and collaboration.

"Education has a decisive role on the personal development of the individual. It is especially important that from an early age the individual should have an effective education that will reflect on his entire life. Along with education, the internal and external factors that condition the development of the individual also play an important role". (Egerău, A.M., Coșarbă, E.M., Torkoș H., 2022).

The pedagogical foundations of STEAM also involve transcending disciplinary boundaries and promoting transdisciplinary and emergent learning (Colucci-Gray et al., 2019). Activities are not fragmented into separate lessons of mathematics, science, or art; rather, they are integrated into fluid learning experiences in which children explore real and complex phenomena. For example, building a bridge from recyclable materials simultaneously incorporates engineering, physics, geometry, artistic expression, and ecological awareness.

In STEAM education, the child is seen as an active agent of learning. Curriculum design and teaching strategies are adapted to the child's interests, needs, and individual rhythm of development. Observation, developmental benchmarks (RFIDT, 2024), and continuous feedback allow educators to personalize learning experiences while ensuring equitable access to inquiry and cognitive growth.

A key pedagogical principle of STEAM is the integration of technology not as passive instruction, but as a tool for creation and exploration. Educational robots, interactive apps, and digital platforms encourage visual programming, 3D modeling, simulation, and creative communication, all of which develop computational thinking and adaptability in digital environments.

Finally, STEAM education is grounded in principles of inclusion and equity, providing all children regardless of ability or cultural background with access to rich and innovative learning experiences. Collaboration with families represents a vital component of this process: parents become partners in education, contributing to a continuous learning ecosystem between preschool and home.

Thus, the pedagogical foundations of STEAM in early childhood configure a child-centered, interactive, transdisciplinary, and experience-based learning model. This approach prepares children not only for school, but for a rapidly changing world in which creativity, critical thinking, and collaboration are essential for personal and social success.

The involvement of students in STEAM activities for the development of 21st-century pedagogical competences

Initial teacher education involves far more than the accumulation of theoretical knowledge; it requires the development of a flexible, reflective, and adaptive professional identity aligned with the demands of contemporary education. In this regard, the active integration of students in STEAM activities and projects becomes an essential pedagogical tool, as it enables them to experience teaching both from the perspective of the child and from that of the future educator. Through direct participation in workshops, experiments, and interdisciplinary projects, students develop not only methodological skills but also metacognitive and socio-emotional competences, which are fundamental to a child-centered pedagogy (OECD, 2021). STEAM education serves as a bridge between academic theory and professional teaching practice by encouraging students to design, implement, and evaluate authentic learning situations based on inquiry and exploration (Quigley & Herro, 2016). This approach supports the transition from a passive role specific to traditional training to an active one, in which the student becomes a designer of learning environments, consistent with Laurillard's (2012) "teacher-as-learning-architect" paradigm.

From the perspective of professional competence development, involvement in STEAM activities strengthens curriculum design skills, critical thinking, and pedagogical reflection. Practical experience requires future educators to adapt strategies according to the developmental level of children and the zone of proximal development (Vygotsky), developing what Fullan and Quinn (2017) refer to as "adaptive capacity" the ability to adjust pedagogical action in real time.

Furthermore, in STEAM-based contexts, experiential learning strategies (Kolb) and project-based pedagogy (Kilpatrick) are not merely understood conceptually but internalized procedurally: students experience the full instructional design cycle exploring themes, defining objectives, preparing resources, facilitating investigation, and assessing outcomes which contributes to the development of systemic pedagogical thinking (Moyer-Packenham & Westenskow, 2022). This experiential process aligns with mentorship-based learning and reflective practice, reinforcing the emergence of the innovative educator profile required in 21st-century education.

Another defining element of STEAM training is the development of computational thinking, regarded today as a form of emergent cognitive literacy (Wing, 2017). Through the introduction of digital tools educational robots, interactive applications, visual programming students come to understand how technology can function as a catalyst for active learning rather than as a passive means of instruction. This paradigm shift helps them distinguish between using technology as a consumption medium and using it as a space for knowledge construction (Roehrig et al., 2021). Familiarity with digital tools also enhances their ability to design educational scenarios adapted to the needs of digital-native children, thus developing intelligent digital pedagogy, a highly demanded competence in today's educational field.

In addition, STEAM activities reinforce cohesion between theoretical, practical, and attitudinal dimensions of teacher training, facilitating the internalization of inclusive education values. Within STEM/STEAM workshops, students have the opportunity to apply differentiation strategies and adaptive scaffolding, developing sensitivity toward learner diversity and understanding that every child can participate regardless of pace or learning style (Paniagua & Istance, 2018). In this sense, STEAM fosters a pedagogy of equity grounded in equal access to meaningful learning experiences.

Finally, participation in such activities cultivates pedagogical leadership and professional collaboration. Students learn to work in teams, to share ideas, to negotiate solutions, and to take responsibility for their contribution to the final learning product. Collaboration is thus both a learning process and an educational outcome, preparing future educators to act as facilitators of learning communities (OECD, 2021).

"The motivation for learning illustrates the determination each student has towards this important process. When the motivation starts from within each student, we say that it is an intrinsic motivation, and when it comes from the outside, we will call it an extrinsic motivation".
(Roman, A., F., Felea, M.I., 2022).

Therefore, the involvement of students in STEAM activities is not a simple methodological addition to traditional practice but a genuinely transformative strategy for initial teacher education, allowing for the integrated development of key 21st-century competences: creativity, pedagogical reflection, adaptability, innovation, digital literacy, and socio-emotional sensitivity. Through this approach, universities prepare not only graduates who know the theory of early childhood education, but professionals capable of reinventing it through practice.

Example of a STEAM workshop carried out at Aurel Vlaicu University of Arad

The following examples illustrate a series of STEAM-based activities implemented during a workshop held at Aurel Vlaicu University of Arad, within the EFASTUD student conference (October 2025), with the participation of first- and second-year students enrolled in Early Childhood and Primary Teacher Education (PIPP).

SCIENCE – Activities for Preschool and Primary Level

Preschool

Title: *Floating Planets*

Operational objective:

O1 – to use a pipette to create colored planets, developing fine motor skills and imagination.

Materials: bowl, colored liquids (blue, orange, green, purple), pipettes

Methods: demonstration, explanation, observation, conversation

Primary

Title: *Craters on the Moon*

Operational objective:

O1 – to understand that the surface of the Moon (and other celestial bodies) is covered with craters formed by impact.

Materials: tray, flour, cocoa powder, ruler
Methods: demonstration, explanation, observation, conversation

TECHNOLOGY – Activities for Preschool and Primary Level
Preschool
Title: *My Space Rocket*
Operational objective:
O1 – to recognize technological objects used to reach space (rocket, space shuttle, telescope).
Materials: balloons, paper tube, colored paper, glue, string
Methods: demonstration, explanation, observation, conversation
Primary
Title: *The Fun Solar System*
Operational objective:
O1 – to build a simplified model of the solar system by ordering the planets according to their distance from the Sun.
Materials: orange, toothpicks, modelling clay
Methods: demonstration, explanation, observation, conversation

ENGINEERING – Activities for Preschool and Primary Level
Preschool
Title: *Our Powerful Sun*
Operational objective:
O1 – to explore simple notions of engineering by creating an object that emits light.
Materials: disposable cup, flashlight, colored paper
Methods: demonstration, explanation, observation, conversation, exercise
Primary
Title: *Planet-Exploring Rover*
Operational objective:
O1 – to apply science and engineering knowledge to construct a functional model.
Materials: small cardboard boxes, straws/skewers, plastic bottle caps, adhesive tape, glue, scissors, colored cardboard
Methods: demonstration, explanation, observation, conversation, exercise

ART – Activities for Preschool and Primary Level
Preschool
Title: *The Happy Sun*
Operational objective:
O1 – to use unconventional materials to create an artistic composition.

Materials: A4 sheet, pasta, colored paper
Methods: demonstration, explanation, observation, conversation, exercise
Primary
Title: *Miniature Solar System*
Operational objective:
O1 – to name and order the planets of the solar system in relation to the Sun.
Materials: disposable cup, polystyrene balls, skewers, paint
Methods: demonstration, explanation, observation, conversation, exercise

MATHEMATICS – Activities for Preschool and Primary Level
Preschool
Title: *Planets Reunite in Space*
Operational objective:
O1 – to correctly match the corresponding halves of the planets using the given materials.
Materials: halved planets (picture cards), glue, string
Methods: demonstration, explanation, observation, conversation, exercise
Primary
Title: *Cosmic Multiplication Race*
Operational objective:
O1 – to perform rapid calculations in a playful context.
Materials: game board, cord/string, dice, rocket tokens, number cards, markers
Methods: demonstration, explanation, observation, conversation, exercise.

Conclusions

STEAM education at the preschool and primary level emerges as an innovative pedagogical approach capable of responding to the challenges of contemporary society by fostering the early development of integrated competences essential for children's adaptation to complex learning contexts. Grounded in constructivism, experiential learning and project-based pedagogy, STEAM represents a transdisciplinary learning framework in which knowledge is not transmitted, but co-constructed with the child through exploration, guided investigation, and reflective practice. This paradigm transforms the role of the educator from a transmitter of content into a facilitator of discovery and mediator of meaning-making.

At the same time, the analysis of students' involvement in STEAM activities demonstrates the major impact of this approach on the initial stages of professional teacher education. Participation in workshops, projects, and authentic learning contexts enables students to move from a theoretical understanding of the curriculum to a practical and reflective application of it, developing higher-order pedagogical competences such as instructional creativity, adaptive capacity, collaboration, critical thinking, and digital literacy. STEAM thus becomes a formative environment in itself, strengthening the professional identity of future educators and preparing them to meet the real needs of digital-native learners.

The practical examples provided illustrate that STEAM facilitates both vertical alignment in learning (from preschool to primary level) and the creation of strong links between theory and practice in university training. Students learn to design child-centered learning situations, implement curricular adaptations, and use technology as a tool for knowledge construction rather than as a simple illustrative aid. Furthermore, the development of computational thinking and the use of digital instruments lay the foundation for the emergence of a professional profile aligned with the demands of the school of the future.

Therefore, STEAM plays a dual formative role: it supports the holistic development of the child and simultaneously innovates initial teacher education by transforming pedagogical practice into a reflective, creative, and competence-oriented process. We conclude that the systematic integration of STEAM in university training contributes to shaping educators who are capable of designing meaningful, inclusive, and future-oriented learning environments, thus becoming agents of change in early childhood education.

References

Colucci-Gray, L., Burnard, P., Cooke, C., Davies, R., Gray, D., & Trowsdale, J. (2019). Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21st century learning. Oxford Review of Education, 45(2), 1–19.

Egerău, A. M., Coșarbă, E. M., & Torkoș, H. (2022). The Value of Formal Education in the Personal Development of Primary School Pupils. Journal Plus Education, 30(1), pag.34.

Fullan, M., & Quinn, J. (2017). Coherence: The right drivers in action for schools, districts, and systems. Corwin.

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice Hall.

Laurillard, D. (2012). Teaching as a design science: Building pedagogical patterns for learning and technology. Routledge.

Ministerul Educației. (2019). Curriculum pentru educație timpurie. MEC.

Ministerul Educației. (2024). Repere fundamentale pentru dezvoltarea învățării timpurii (RFDIT). MEC.

Moyer-Packenham, P. S., & Westenskow, A. (2022). Early childhood STEAM: A transdisciplinary approach to developing mathematical thinking. Early Childhood Education Journal, 50(5), 823–838.

OECD. (2021). Teachers and leaders in STEAM education: International perspectives on innovation. OECD Publishing.

Paniagua, A., & Istance, D. (2018). Teachers as designers of learning environments: The importance of innovative pedagogies. OECD Publishing.

Quigley, C. F., & Herro, D. (2016). "Finding the joy in the unknown": Implementation of STEAM teaching practices in middle school science and math classrooms. Journal of Science Education and Technology, 25(3), 410–426.

Roehrig, G. H., Dare, E. A., Ring-Whalen, E., & Wieselmann, J. R. (2021). Understanding coherence and integration in integrated STEM education. International Journal of STEM Education.

Roman, A. F., & Felea, M. I. (2022). The Motivation of Learning in Students. Journal Plus Education, 31(8), pag.10.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Weisberg, D. S., Hirsh-Pasek, K., Golinkoff, R. M., & McCandliss, B. D. (2016). Guided play: Principles and practices to promote learning. Cognitive Development, 39, 59–74.

Wing, J. (2017). Computational thinking: What and why. The Link Magazine, 12(1), 20–23.