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STREAM role models 4 ALL: A project supported by Scientix STE(A)M Partnership Education Resilience in Europe

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ABSTRACT

STREAM role models 4 ALL project serves as a comprehensive guide for educators aiming to integrate STEM education into their classrooms. Emphasizing the incorporation of art into STEM education, the project advocates for a STEAM approach that fosters students' exploration, discovery, and engagement in innovative engineering skills. It underscores the benefits of employing pedagogical methods such as inquiry-based learning and problem-based learning to cultivate active learning, deeper knowledge, and critical thinking skills. Furthermore, the project underscores the significance of computational thinking in shaping problems and expressing solutions in a manner conducive to efficient computer execution. Addressing the challenges encountered by schools when implementing STEM approaches, including the necessity for teacher training, access to resources, and the creation of a supportive classroom climate, the project offers valuable insights. Overall, STREAM role models 4 ALL project provides a valuable resource for educators seeking to promote STEM education and equip students with the skills to address global challenges through exploration, discovery, and creative problem-solving.

Keywords: computational thinking, inquiry-based learning, problem-based learning, STEM approach

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INTRODUCTION

Over the last few years, there has been a growing interest in STEM approaches at all levels of education. Education based on a STEM approach aims at preparing children to solve global issues through exploration, discovery, creative and critical thinking, collaboration, effective interaction, and communication (Quigley & Herro, 2016). It is an approach that removes the boundaries between disciplines and considers them as a 'whole', on the basis that contemporary problems are complex and multidimensional enough to be addressed by a single discipline (Tsupros et al., 2009).

In a constantly changing world, schools cannot remain inactive to these developments, as scientific literacy is essential for life today. Research implemented in the field of preschool education with children participating in STEM activities concluded that the age of children is not a limiting factor but rather benefits them in developing and cultivating a variety of skills, just as it is for older children (Bagiati & Evangelou, 2015; Lyons & Tredwell, 2015).

It is important to consider whether current STEM practices are sufficient to prepare students for the world in which they live and work. This necessitates discussions about STEM (science, technology engineering, mathematics), which is an important, innovative concept now, with a trend of integrating art into STEM education–and ultimately becoming STEAM (Yakman & Lee, 2012) as well as literacy and literature (reading and writing) transforming STEAM into STREAM (Foti, 2023). STREAM offers educators the opportunity to simultaneously integrate multiple disciplines, advancing the learning process through experiential opportunities that enable children to become explorers themselves, ask questions, discover, and engage in innovative engineering skills (Foti, 2021a).

STREAM PEDAGOGICAL APPROACHES

STEAM learning starts very early in young children's lives, through the daily actions they engage in. For example, it includes looking at shapes, making cardboard forts or paper boxes, pouring liquids and other materials, filling/emptying containers of different sizes or mixing colors to create new ones. And these are just a few examples (Foti, 2021b).

Many children's everyday activities use STEAM skills, even if we do not think of them exactly that way. When young children play, explore, and develop skills and theories about the world, or when they explore their environment, they experience the fulfillment that can come from inquiry, discovery and problem-solving, while adults can foster the development of these STEAM skills in children by providing them with learning opportunities and materials that support exploration and discovery (Foti & Rellia, 2020). Furthermore, STEAM activities are interactive and inquiry-based, providing many opportunities for active involvement, including children who are learning two languages at the same time or who come from different socio-cultural backgrounds.

Based on John Dewey's principle that education begins with curiosity (Savery, 2006), this scientific approach encourages young children to go through all the stages of research: asking a question, setting up a hypothesis and planning how to test it, collecting data, analyzing the results, and sharing them with their peers (Pedaste et al., 2015).

Computational thinking (CT) is a cognitive process involved in shaping a problem and expressing its solutions in such a way that a computer–whether human or machine–can efficiently execute it (Wing, 2014). According to researchers (Psycharis & Kotzampasaki, 2019), the fundamental dimensions of CT include abstraction, algorithm, decomposition, generalization, and evaluation. It is noted that technology, specifically through programming, aids students in developing CT.

Inquiry-based science education approach is ideal for science education because it transforms teaching into a more hands-on experience: students learn how to articulate questions and answers through experimentation, while the teacher plays the role of both a facilitator and an educator (Foti, 2021a). The utility of inquiry-based learning (IBL) and understanding is significant because it is a pedagogical approach that allows students to become researchers themselves; the teacher either guides students in the form of scaffolding or allows them to explore the task independently; it can be combined with other pedagogical methods and practices to enhance the meaning and effectiveness of learning.

Problem-based learning (PBL) is an educational method that focuses on practical and active learning, aiming at exploring and seeking solutions to real-world problems. Teachers try to encourage children in developing new skills/assimilating new knowledge and using preexisting one while confronted with solving a problem (Nunes et al., 2017). Learning by inquiry and implementation of knowledge and skills is aimed at discovering a viable solution to a defined problem and converting pupils into skilled problem-solvers in the real world. According to Barrows (1996), PBL is problem-focused and is student-centered, self-directed, self-reflective, and collaborative while the teacher has the role of a teacher-facilitator.

The choice of open-ended problems (often interdisciplinary), the pupil-centered approach and the support provided to guide the learning process and ultimately inform the educational experience by the teacher without providing ready-made possible solutions or information about the problem and instead expecting students to work to gather data and propose solutions to a potential problem are essential elements for the success of PBL (Patrinopoulos & Iatrou, 2019; Savery, 2006).

Project-based learning is a way of learning based on constructivist theories in which students better understand knowledge by working with others and using their own ideas. Teachers design activities based on question or problem-solving and students, through a process of inquiry and creation, produce a final collaborative product that is presented to the whole class.

One of the advantages of this approach is its interdisciplinary nature since the same project may eventually have more than one solution. Students are free to choose their own strategies and approaches to problem-solving, elements, which will influence their thinking more broadly, as well as concepts such as teamwork, collaboration, listening and respect for the opinions/presentation skills of others are at the heart of this method (Falik et al., 2008). However, the role of the teacher, as a facilitator of learning, is stronger, while the role of students in setting the goals and parameters for the research is less defined (Boon & Van Baalen, 2019).

The introduction of a design activity at the beginning or end of a group task gives students the opportunity to apply their newly-acquired knowledge to complete an assignment that has been given to them, as design and research with a specific purpose combine technological design with scientific research in the context of problem-solving (Asunda, 2014; Sanders, 2009). Focusing on authentic problems offers students the opportunity to make connections between different cognitive subjects and develop problem-solving, diagnostic, and critical thinking skills, including research, hypothesis testing, analysis, synthesis, and deductive reasoning, to find solutions to real problems.

IBL is an active method that allows students to think and justify their thinking, as well as to create their own learning. Therefore, this method does not involve memorization or learning of basic concepts but the application and assimilation of the necessary processes for knowledge production and development. The benefits of this method are the promotion of active learning, deeper and more substantive knowledge, effective evaluation, adaptability, and the development of lifelong skills and abilities for students (Swartz et al., 2010).

IBL has proven to be a very useful tool for promoting STEM research among children of both genders from a very young age (Tindall & Hamil, 2004) and is particularly effective when integrated into a suitable and engaging curriculum. Through this approach, children gain experiences that allow them to question, collaborate, think critically, solve problems, exchange ideas, and discover new knowledge.

Guided discovery, especially for kindergarten and early elementary school children, can be a developmentally appropriate practice when our goal is for children to understand topics that we can present with specific examples. This process provides the support framework that entails gradual assistance provided to children to complete activities they cannot accomplish on their own (Gredler, 2012).

The specific STEAM methodology provides educators with the opportunity to use teaching and learning strategies based on programs that incorporate all five fields and create an inclusive learning environment, where all students can participate and contribute. In contrast to traditional teaching models, educators using the STE(A)M methodology follow approaches in which students can cultivate and enhance numerous significant skills (Psycharis et al.,2020, 2022).The constructive teaching approach, based on Vygotsky's socio-cultural theories, which is employed in the instructional scenarios included in this project supported by Scientix STE(A)M Partnership Education Resilience in Europe and implemented in the classroom, comprises five phases/stages: orientation, eliciting student ideas, restructuring ideas, applying new ideas, and reviewing. The goal of learning is to modify existing knowledge, while the goal of teaching is to create suitable and rich environment in which students interact. software, the creation of engineering structures, the cultivation of mathematical thinking, and the acquaintance with basic principles of programming and algorithmic thinking, children encounter the philosophy of STE(A)M from a very early age (Foti, 2022; Foti & Rellia, 2023).

FRAME OF THE PROGRAM

ST(R)EAM role models 4 ALL project was designed and implemented within the framework of the "education resilience in Europe" initiative, which is supported by the Scientix STE(A)M Partnerships program and funded by Cisco. This initiative aims at addressing the challenges associated with the integration of students from different cultural and linguistic backgrounds. In this effort, ST(R)EAM role models 4 ALL project was one of ten selected projects from across Europe. This five-month project had the primary goal of developing best practices in inclusive STEM education.

Scientix, the European community for scientific education, fosters collaboration between educational ministries, schools, educators, and other stakeholders. It strives to create research initiatives that introduce new educational approaches, nurture creativity, and offer innovative teaching and learning opportunities in STEM fields. ST(R)EAM role models 4 ALL project was implemented in Greece and aimed to design and apply pedagogical scenarios centered around collaborative STEM activities.

The implementing schools included schools in urban areas, some of which have a large percentage of Roma students, but also schools from small villages in island regions far from urban centers.

ST(R)EAM role models 4 ALL project focused on creating and implementing educational initiatives tailored to students in their early years of schooling, including preschool and early elementary grades. The primary target audience for this project was students from diverse cultural and linguistic backgrounds. The goal was to cultivate positive STEM identities among these young learners by exposing them to meaningful STEM experiences. One unique feature of this project was its emphasis on collaboration. It encouraged educators from various school units to work together and involved parents in the process. This collaborative approach aimed at enhancing the project outcomes and ensure its success. ST(R)EAM role models 4 ALL project involved close cooperation among the project team, educators, and parents. The project implementation was a multistage process that aimed at providing an enriching educational experience for the students. The active involvement of parents in the project planning and execution was a vital component of its success.

Before the project official launch, parents were informed about the initiative and enthusiastically encouraged to contribute to its achievements. Their early buy-in was instrumental in creating a supportive environment for students both at school and at home, ensuring that the benefits of STEM education would reach beyond the classroom. During the project implementation phase, a strong partnership was fostered with educators from the participating schools. This collaboration was nurtured through a series of focused group meetings, where educators came together to share their insights, experiences, and best practices. These collaborative sessions became invaluable platforms for peer learning, enabling the dissemination of effective teaching strategies and methodologies. To address the project goals, the project team designed ten innovative lesson plans. These lesson plans were meticulously crafted, taking into consideration the students' age and interests, with the overarching aim of promoting exploratory learning. By integrating real-world challenges and handson activities, the plans encouraged students to work together in groups, utilizing a combination of readily available materials and digital tools. These lesson plans not only facilitated the acquisition of STEM knowledge but also nurtured essential skills such as problem-solving, critical thinking, and teamwork, ensuring a holistic development of the participating students.

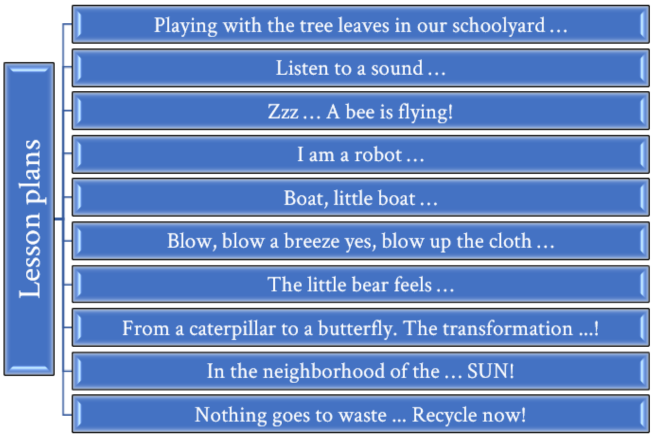

Figure 1. Lesson plans (Source: Authors)

In essence, the collaboration among educators, parents, and the project team created an educational ecosystem, where students were at the center of a dynamic and engaging learning experience. It underscored the importance of cohesive efforts in enriching STEM education and equipping students with the skills they need to thrive in an ever-evolving world.

The lesson plans featured in the project covered a diverse array of topics and concepts, effectively bridging different subject areas within STEM. They were intentionally crafted to promote CT and enhance students' problem-solving abilities, placing a strong emphasis on encouraging collaborative efforts among students. One of the distinctive features of these lesson plans was their relevance to real-life scenarios, ensuring that students could directly relate the content to their daily lives. By focusing on practical, real-world issues, the lessons not only made STEM education more engaging but also underscored its significance in addressing everyday challenges. The integration of these interdisciplinary lesson plans encouraged students to think critically and develop a deeper understanding of STEM principles. It also facilitated a seamless transition between theoretical knowledge and practical application, enabling students to see the tangible impact of STEM education in their own lives. As a result, students not only gained knowledge but also developed essential life skills that would serve them well beyond the confines of the classroom.

10-lesson plans are shown in **Figure 1**.

One notable achievement of the project was the successful engagement of preschool educators. Despite lacking a specific STEM background, these educators enthusiastically embraced pedagogical activities alongside their young students. Surprisingly, numerous activities initially unrelated to STEM education received overwhelmingly positive responses when introduced. This phenomenon highlights the educators' adaptability and the project capacity to broaden their pedagogical horizons. Their willingness to experiment with STEM concepts enriched the learning experience for students, demonstrating the power of inclusive teaching practices. The

Figure 2. Experimentation activities with simple materials (Source: Authors)

Figure 3. Student activities with simple materials & digital media (Source: Authors)

project served as a catalyst for educators to explore STEM education, enhancing their versatility and fostering a spirit of curiosity among the students. In this way, the project made a significant impact by not only reaching students but also by inspiring educators to embark on a STEM journey. **Figure 2** shows experimentation activities with simple materials.

The active involvement of parents in the project, especially in activities extended at home, stands as a noteworthy accomplishment. This deepened their comprehension of STEM education, fostering a stronger bridge between school and families. It encouraged a collaborative approach to learning and allowed parents to actively participate in their children's educational journey.

This engagement not only enriched the students' learning experiences but also underscored the project commitment to holistic STEM education. It facilitated open communication between schools and families, making them active stakeholders in the learning process. This shared responsibility for STEM education ultimately reinforced the importance of parental involvement in shaping well-rounded, future-ready students. **Figure 3** shows student activities with simple materials and digital media ST(R)EAM role models 4 ALL project, implemented within the broader "education resilience in Europe" initiative, stands as a testament to the value of collaborative efforts in promoting inclusive STEM education. By actively involving educators and parents, the project succeeded in providing young students with meaningful STEM experiences and fostering positive STEM identities.

The project impact extended far beyond the classroom. By implementing innovative lesson plans and prioritizing exploratory learning, it not only bolstered students' technological proficiency but also cultivated their CT, problem-solving prowess, and collaborative mindset. Students became active participants in their own education, developing skills crucial for the modern world, such as critical thinking and creativity. Moreover, the project inclusion of parents as partners in the educational process was instrumental in amplifying its reach. This collaboration bridged the gap between school and family, forging a strong alliance in the advancement of STEM education. It was not just about academic involvement; it was about fostering a culture of curiosity and learning at home, too. Parents gained insights into their children's educational journey and were equipped to support and encourage their STEM-related interests.

This synergy transformed the learning experience into a joint venture, solidifying the importance of holistic STEM education in building well-rounded, future-ready students. In essence, the project's multifaceted approach, blending innovative pedagogy, collaborative learning, and parental engagement, enriched students academically, socially, and personally. It laid the foundation for a new generation of learners who are not just proficient in STEM but also capable of adapting to the evolving challenges of the 21st century. It's a testament to the transformative power of education when all stakeholders work together towards a common goal.

SUMMARY

ST(R)EAM role models 4 ALL project has been a model for inclusive STEM education that promotes diversity and collaboration, ensuring that students from diverse cultural and linguistic backgrounds can thrive in the world of STEM.

From the project design, implementation and results it is clear that:

1. The pedagogical framing of activities with topics that attract children's interest is necessary.
2. The appropriate design of educational material and educational support from teachers can allow children through playful activities (tinkering STEM approaches) to approach concepts and processes that we consider to be addressed to older ages. This is compatible with the literature that children have a spontaneous tendency to explore processes and construct/find solutions through play (Chesloff, 2013; Patrinopoulos & Iatrou, 2019).
3. Teachers when given the right support and time have the ability to support STEM activities.
4. The information and participation of parents is a decisive factor in consolidating the results of these interventions.
5. Positive learning outcomes are directly related to the age students began participating in such activities and the duration of their involvement with experiential activities (Freeman et al., 2014).

Finally, perhaps the most important result that we were able to extract is that the application of collaborative approaches with experiential actions affects not only the cognitive field of the participants but also reshapes the classroom climate, strengthens the relationships between children and allows the inclusion of students from different social and cultural backgrounds.

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Declaration of interest: The authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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