Journal of Innovation in Psychology, Education and Didactics
ISSN: 2247-4579, E-ISSN: 2392-7127
http://www.jiped.ub.ro/
Covered in: EBSCO, CEEOL, ProQuest, ERIH PLUS, DOAJ, Scipio, International Innovative Journal Impact Factor, CiteFactor, EuroPub database, Open Academic Journals Index, ResearchBib, Universal Impact Factor
2025, Volume 29, Issue 1, pages: 133-146, doi:10.29081/JIPED.2025.29.1.10

Key Competencies, Teaching Instruments Specific to S.T.E.M. and Holistic Development in Primary School Education

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Received: 09 January 2025/ Accepted: 01 September 2025/ Published: 03 September 2025

Abstract

S.T.E.M. competencies (science, technology, engineering, and mathematics) represent a fundamental need of the current moment, given that they represent a form of basic literacy that involves knowledge, skills, and abilities in the six fundamental areas for the development and shaping of perspectives that support innovative talents. Primary school teachers must have a consistent academic preparation in order to be able to develop STEM competencies. In this paper, we have described how primary school teachers can use tools in educational contexts that can favor the emergence and development of children's potential to learn scientifically and explore the specifics of S.T.E.M. domains. The tools that facilitate the entire process of forming these acquisitions are important. Depending on the teaching skills of each teacher, the most appropriate tools for developing STEM skills can be selected. The process of selecting the most appropriate tools for developing STEM skills is not an easy one for teachers. To support primary school teachers, we have structured for each type of S.T.E.M. competence some of the tools that can be used to develop the ability to solve problems, critical thinking, creative thinking, and the ability to analyze or observe, with examples of the use of some of them. Also, in addition, we have made connections between S.T.E.M. competencies and the specific dimensions of a holistic development of the child. The most harmonious development of a balanced and adaptable personality of the child, future adult, can be achieved by applying an integrated model of holistic development that targets at least five dimensions: cognitive, social, emotional, physical, and spiritual. This integrated approach helps to recognize and understand the complexity of child development. All dimensions are interconnected, and, therefore, it is important that the education and support offered to children be in a holistic and balanced manner. In this paper, we have referred to each dimension, focusing on how S.T.E.M. education can contribute to the development of each of them.

Keywords: games; holistic development; key competencies; primary school education; STEM education; teaching instruments

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How to cite*:* Massari, G.-A., & Ciubeică, L. (2025). Key competencies, teaching instruments specific to S.T.E.M. and holistic development in primary school education. *Journal of Innovation in Psychology, Education and Didactics*, *29*(1), 133-146. doi:10.29081/JIPED.2025.29.1.10

1. Key Competencies Specific to S.T.E.M. Education

STEM education is the main trend of education reform in countries all over the world (Hu & Guo, 2021). The S.T.E.M. (Science, Technology, Engineering, and Mathematics) approach is a metadiscipline that supports integrated learning, facilitating the approach to problems in real-world contexts. It goes beyond the simple accumulation of knowledge from individual fields, stimulating pupils to collaborate, develop critical thinking, and creatively apply concepts. Modern society needs individuals capable of formulating essential questions, developing innovative solutions, and acting in an organized way by creating plans, while making connections with the surrounding reality. One of the main objectives of S.T.E.M. education is to guide children in exploring and discovering these solutions through various methods and approaches.

S.T.E.M. competencies emphasize the development of interdisciplinary and transdisciplinary skills within education, aiming to form critical and creative thinking and promote collaboration and communication through problem-solving. These competencies integrate science, technology, reading, arts, engineering, and mathematics, giving pupils the chance to apply knowledge in practical contexts relevant to their daily lives. S.T.E.M. activities transform learning from a purely theoretical process into an applied one, preparing pupils to address the complex challenges of modern society and to become innovators in different fields.

By approaching these fields in an interdisciplinary manner, pupils are encouraged to develop their ability to apply knowledge holistically and to address the complex challenges of the contemporary world. These skills should be integrated into the school curriculum and actively promoted in the learning process to provide pupils with a solid foundation for the future. Epistemological, procedural and technical knowledge constitute essential elements of STEM knowledge, highlighting both the interconnections between the concepts and theories of individual disciplines and the role of procedural knowledge in the acquisition and application of STEM skills, such as measuring and evaluating data, determining its accuracy, validity and reliability, and selecting and displaying it, while technical knowledge focuses on the effective use of knowledge, skills, attitudes and values in a specific professional context (Soo, 2019).

S.T.E.M. skills are essential in the current context, representing a fundamental form of literacy that includes knowledge, skills, and aptitudes in essential areas. They contribute to the preparation of future adults, facilitating employability in the labor market and promoting the development of innovative solutions. Hu & Guo (2021) argue for the need to cultivate the key competencies of 21st-century talents because the rapid penetration and wide application of the internet, artificial intelligence technologies, technological products, and big data in everyday life are leading to an increasingly close relationship between society, science, and technology. Key findings of the Future of Jobs Report from 2020 are: creativity, originality, and initiative; active learning strategies; innovative technology development and programming; emotional intelligence; critical thinking and systematic analysis; complex problem-solving; analytical thinking and innovation; problem-solving and ideation; service orientation; resilience, stress tolerance, and flexibility; leadership and social impact; systems analysis and evaluation; persuasion and negotiation; technology use, monitoring, and control; instruction, mentoring, and teaching (Abina et al., 2024).

The ATS STEM conceptual framework generated a comprehensive taxonomy of essential STEM skills, structured into eight fundamental categories—problem solving, innovation and creativity, communication, critical thinking, meta-cognitive skills, collaboration, self-regulation, and disciplinary skills—that systematizes the 243 specific skills, thus facilitating a more precise

understanding and assessment of this multidimensional field. The UNESCO framework for STEM competencies is presented in Figure 1.

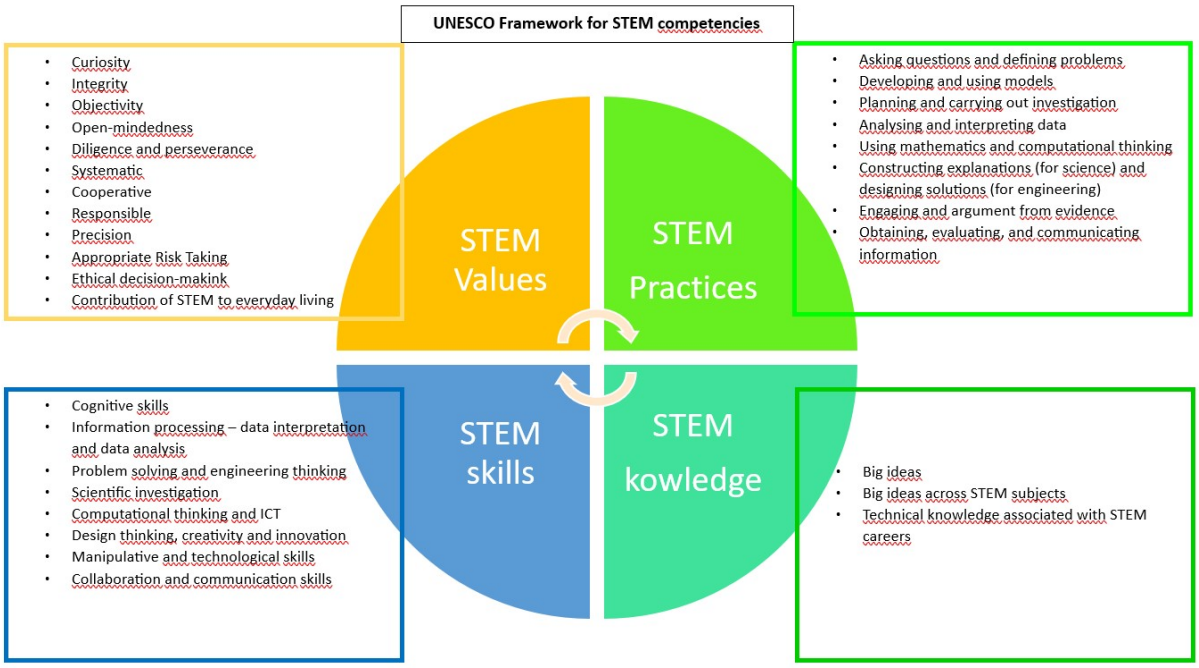

Figure 1. UNESCO Framework for STEM competencies

S.T.E.M. competencies bring together science, technology, engineering, and mathematics in an integrated approach that focuses on the development of inter- and transdisciplinary skills in education, to cultivate critical and creative thinking, as well as promoting collaboration and communication through problem solving. These competencies must be included in the school curriculum and are actively promoted in the learning process, in order to give pupils the chance to apply knowledge in a practical and relevant way for everyday life. As a coherent and interdisciplinary approach to cultivating interdisciplinary knowledge and skills in the fields of science, technology, engineering, and mathematics, STEM education has been included in educational policy documents in China, the United Kingdom, Germany, South Korea, and Finland (Saxton et al., 2014).

According to Șuteu et al. (2024), the main competencies specific to S.T.E.M. education include understanding problematic situations and approaching them from a transdisciplinary perspective. Thus, the child develops the ability to analyze various learning situations, capitalizing on specific S.T.E.M. knowledge. At the same time, critical and creative thinking is developed, essential skills for pupils who face complex problems that require innovative solutions. Bruning et al. (2004) highlighted four themes that are closely correlated with S.T.E.M. education. They emphasize that learning must be perceived as a constructive process and not as a passive act with the role of receiving information. Through S.T.E.M. activities, learning becomes both theoretical and applied, preparing pupils to face the complex challenges of modern society and to become innovators in various fields. In this sense, motivation and belief systems are harmoniously integrated into the learning process, profoundly influencing the way in which knowledge is accumulated. Through an interdisciplinary approach, pupils are encouraged to develop their ability to apply knowledge holistically, thus addressing the complex challenges of the contemporary world. At the same time, social interaction plays an essential role in cognitive development, facilitating the exchange of ideas and collaboration between pupils. Last but not

least, knowledge, strategies, and skills are contextual, which means that they are influenced by the environment in which they are applied. Akiri et al. (2021) argues that within S.T.E.M. education, the student's self-criticism capacity is developed, the ability to collaborate and be open to new ideas when solving a problem, and finding solutions. The desire for involvement in the learning process is also intensified; more precisely, motivation is considerably developed.

Two important acquisitions that can be developed within S.T.E.M. education and are closely related are critical thinking and creative thinking. J. Dewey (1910) argues that critical thinking is a process of "active, persistent, and careful examination of a belief or a supposed form of knowledge in the light of the reasons that support it and the subsequent conclusions that it tends to", being the equivalent of reflection, and which plays an important role in the instructional-educational process. R. Sternberg (1996) reports that the concept of creativity is three-dimensional. Creativity is based on three characteristics: it requires synthesis (the ability to observe certain problem situations from multiple perspectives), analysis (the ability to identify which ideas are worth considering), and contextualization (the ability to convince others of the values we promote). Creative thinking offers numerous benefits to individuals and develops a series of essential traits that help them adapt to a constantly changing society. Thus, pupils who demonstrate creative thinking are characterized by curiosity (they ask varied questions and are eager to obtain as much information as possible), tenacity (they do not give up easily in the face of challenges), collaborative spirit (they share their ideas with other members of the group), discipline (they approach work seriously and constantly aspire to self-improvement) and imagination (they make connections with various aspects of reality, developing this capacity playfully). These traits offer a deeper perspective on the concept of creativity. Although these dimensions are often neglected in the educational process, in S.T.E.M. education, they are cultivated through transdisciplinary approaches.

The fundamental acquisition specific to S.T.E.M. to understand and solve problems is equivalent to the concept of computational thinking. This thinking does not only exist within S.T.E.M. education, but also in other humanities disciplines. This acquisition can be capitalized through robotics since the connection between science and technology can be observed. The concept of computational thinking was first used by Seymour Papert in 1980, and he believes that this type of thinking offers people opportunities to use various means of representing and interacting with information, respectively, a new way of "objects to think with". Then, in 2011, Jeannette Wing promoted this concept: "the thinking processes involved in formulating problems and solving them, so that solutions are represented in a form that can be efficiently realized by an information processing agent". Riopel et al. (2019) conducted a meta-analysis of 79 studies on serious games (i.e., digital software explicitly designed for learning purposes) in science education and reported that knowledge construction and internalization (e.g., declarative and procedural knowledge, knowledge retention) scored slightly higher for pupils. Robotics represents an opportunity in which pupils develop their problem-solving skills. They come into contact with state-of-the-art digital devices. These are also found in the fields of activity in contemporary society, and schoolchildren become familiar with such objects early on. Computational thinking is included in problem-solving situations in the fields of science, but also in the present. However, the first researcher to discuss the concept of robotics for educational purposes was Papert (1984). He considered that pupils can acquire knowledge in the fields of mathematics and physics if they use computers. Later, the development of the programming language and building robots allowed pupils to participate in the teaching-learning process and discover knowledge individually. This process is called constructivism and has been successfully integrated into the field of education. In this regard, the emphasis is on the practical side. In this field, robotics, the teacher must make a connection between practical activities and abstract understanding.

The specific form of organization is that of working in a team, and each member will have a task to complete. Pupils go through a series of steps during a project of this type. For

example, applying the design process, formulating the problem, planning, approving, modifying, and presenting the results. Thus, pupils are put in the context of treating each step with maximum seriousness and, at the same time, proving that they think like future engineers. By going through each step, other skills are developed. For example, in terms of applying the design process, the ability to think computationally is developed. In terms of formulating the problem, pupils develop the ability to decompose. The ability to generalize is developed during planning. A good engineer must plan a detailed plan and discover what steps to follow to solve the problem. Also, within the modification, pupils develop their evaluation skills. This skill is very important when pupils identify a problem and they have to find optimal solutions to fix it. And in terms of presenting the results, pupils develop their communication skills. They briefly present the final product and at the same time, the steps they took, respectively, what difficulties they encountered, but also the methods for solving them. The acquisition of understanding and solving problems plays an important role in S.T.E.M. education as pupils are faced with complex challenges of an interdisciplinary nature, as stated by M. Marin (2023). Pupils make connections with real life in various areas where problems cannot be solved in a monodisciplinary way.

G. Lemeni and M. Miclea (2010) defined critical thinking as the ability to read or listen to the information transmitted, to interpret it objectively, simultaneously evaluating its correctness and importance. S. Sănduleac (2020) states that critical thinking and the ability to analyze are skills that are closely linked, being a cyclical process. It is highlighted that, through the ability to analyze, the student discovers the essence of the subject of interest. Implicitly, the emphasis is on the depth of understanding of the subject addressed. The student cannot get involved in activities if he does not master the content of the presented problem very well. The teaching staff must present the information as organized as possible and focus on relevant aspects, avoiding details that children would not have the opportunity to understand or implement in everyday life. This competence also brings advantages to the student's personality. Following the development of this competence, the student has a positive attitude towards himself, self-respect is shaped, and the attitude towards the world changes. The student discovers what passions he has and what objectives he has to follow to achieve his proposed goals. L. Ciolan (2008) believes that transdisciplinarity consists of combining the learning processes of pupils at the individual level with the needs, interests, and personal characteristics within the educational activities. Therefore, pupils become responsible for their own learning through direct participation. According to the author M. Marin (2023), within the integrated activities, pupils develop a type of transdisciplinary thinking. Transdisciplinary thinking aims to improve critical thinking. Transdisciplinary thinking is a concept that helps people make connections with real life and observe the unfolding of events from multiple perspectives. This thinking can be applied in various situations whose resolution cannot be achieved monodisciplinary approach. At the same time, critical thinking allows pupils to develop the necessary skills for solving problems and discovering the world beyond the boundaries of disciplines. In this instructive-educational process, the teacher develops a positive attitude towards learning and thus contributes to stimulating the interest and motivation of pupils.

Another representative competence of S.T.E.M. education is the ability to analyze. According to the author Rotari et al. (2021), the ability to analyze is equivalent to investigative competence. This competence is specific to the 21st century as pupils must be familiar with the content they produce, synthesize, and evaluate various information with a sense of responsibility. Akiri et al. (2021) report that transdisciplinary education cannot be achieved without analyzing and solving situations with elements of novelty. These stimulate the student's curiosity, motivation, and inspiration. Involving children in various activities contributes to the development of responsibility, and the learning process will be a continuous one, which will unfold naturally, without external demands. Therefore, it is important that all these S.T.E.M. skills - the formation of critical and creative thinking, and the promotion of collaboration and communication through problem solving. - are achieved early. Schoolchildren are considered engineers who solve problems. The teaching staff must stimulate the curiosity of pupils regarding

the STEM fields as they represent the future of society. Many children lose interest in the field of science after completing the primary cycle, and this curiosity that they have from an early age must be maintained.

2. Tools for training specific S.T.E.M. skills

The training of specific STEM fundamental skills plays an important role in the formation of an individual's personality. In addition to the classic acquisitions that the child acquires in the primary cycle, such as the ability to read and write, stimulating the motivation for learning, the student must acquire during the years of study and acquisitions that necessary skills for the labor market. Thus, these acquisitions can be developed through educational platforms and playful tools. The pedagogical methods should also be supported by advanced digital technologies, information and communication solutions, datafication, and artificial intelligence (Haleem et al., 2022). There are numerous current initiatives and practices that teachers adopt to develop key S.T.E.M. skills. Among the most popular strategies are: problem-solving projects, experiential learning activities, technology integration, interactive games and activities, team collaboration, and educational excursions. Lander's theory (2014) of gamified learning illustrates how gamification elements, such as leaderboards, are hypothesized to affect learning performance through autonomous motivation (Self-Determination Theory) and self-efficacy. Chad Stevens said, "By integrating TinkRworks' award-winning PBL curriculum and professional development resources with 1st Maker Space's fully equipped and engaging makerspaces, we can enhance the STEAM learning experience for pupils while simplifying planning and logistics for teachers and schools." Through a quasi-experimental study, Ortiz-Rojas et al (2024) investigated the impact of leaderboard-based gamification on the learning performance of 175 pupils in a calculus course, focusing on the mediating roles of autonomous motivation and self-efficacy, as well as potential moderating factors such as gender and gaming experience. This study highlights how gamified educational environments need to be carefully designed and implemented. Leaderboards can have a large positive effect on learning performance, but pupils' motivation or self-efficacy can be influenced in different ways. There is no one-size-fits-all solution when it comes to effective gamification. However, with the right design, teachers can create a more engaging and effective learning environment, with improvements in academic outcomes. All these initiatives and practices play a crucial role in the formation of key S.T.E.M. skills in pupils. The tools that facilitate the entire process of training these acquisitions are important. Depending on the teaching skills of each teacher, the most appropriate tools for training STEM skills can be selected. The process of selecting the most appropriate tools for developing STEM skills is not an easy one for teachers. To support primary school teachers, we have structured for each type of specific S.T.E.M. skill some of the tools that can be used to develop the ability to solve problems, critical thinking, creative thinking, and the ability to analyze or observe, with examples of how to use some of them.

2.1. Ability to solve problems

Specific S.T.E.M. tools that develop the ability to solve problems are: S.T.E.M. Logic Game – Brainometry, Botley Robot, Colorful Geometric Shapes, S.T.E.M. Construction Set – Little Engineer, MathLink Set – Vehicles from Learning Resources, H2Ohhh! Water Experiment Set, Little Genius Experiments – S.T.E.M. T-Rex Set, S.T.E.M. Logic Game – Pixel Art from Learning Resources, Evo Robot – Classroom Kit.

To exemplify the above, we will present one of the tools that contribute to the formation of fundamental S.T.E.M. acquisitions, namely the S.T.E.M. Logic Game – Brainometry. This educational game is recommended for children with the aim of developing their ability to act logically and solve problems. At the same time, this game stimulates concentration, creativity,

critical thinking, and mathematical skills. This S.T.E.M. logic game is suitable for schoolchildren who want to gain knowledge about the shapes and colors of objects. Through this game, schoolchildren learn about a single subject combining science, technology, engineering, and mathematics. This game also contains 10 challenge cards, geometric shapes of different colors and patterns, plus an activity guide in English. Children receive as a didactic task to solve the requirements that are written on those cards using 3D geometric shapes. At the same time, pupils must show attention, as there is the possibility that a construction may not remain stable. There are also a number of advantages of this tool, for example: it encourages collaboration with other team members, effective communication, and critical thinking. The Brainometry game is suitable for children of different ages and can be adapted according to the cognitive needs of each child.

The Botley robot is a tool that can be used to form fundamental acquisitions specific to S.T.E.M., and which comes to the aid of teachers to complete the school program and to capture the curiosity of children in the S.T.E.M. field. This game is suitable for schoolchildren who are eager to learn about programming languages, more precisely, algorithms, and coding of certain functions in the IT field. The activity set contains the robot, named Botley, domino pieces of different sizes, two balls, a hammer, a turnstile, a glass, and removable arms. All that needs to be done is for pupils to consult the activity guide and program the robot to perform different actions using the materials provided, for example: Botley can play a game of bowling, catch marbles, or play the game of dominoes. This tool can be included in the learning activity both at home and in schools, or in specific courses for learning programming languages for children.

Another tool that outlines this S.T.E.M. competence very well is the S.T.E.M. Building Set – Little Engineer. This game focuses on experiments and problem-solving skills and complements educational activities to spark curiosity about science, technology, engineering, and mathematics. Children can build catapults, windmills, and other objects that they can set in motion. The game is suitable for schoolchildren who want to learn the basics of engineering. While they build, they will discover concepts from the field of physics, namely: force and motion. With a little imagination, schoolchildren can also build other interesting objects that are not in the instruction manual. In addition to this skill, pupils also develop critical thinking and fine motor skills. This game can be played both in the formal school setting and at home, and the main methods of organization are individual or group.

2.2. Critical thinking and creative thinking

Among the specific S.T.E.M. tools that develop critical thinking and creative thinking, we list: S.T.E.M. – Force and Movement, S.T.E.M. Game – Jack the Mouse, S.T.E.M. Construction Set – Little Engineer, Coding Game – Playful Kittens, S.T.E.M. – Interactive Snail Qobo from Robobloq, Circuit Explorer – Space Mission: Lights, Magic Drill – Creative Workshop, Artie Max the Robot.

The S.T.E.M. Set – Magnet Magic is a learning tool that contributes to the development of fundamental S.T.E.M. acquisitions, being a game with an educational purpose in which pupils learn the properties of the phenomenon of magnetism, for example: attraction and repulsion, respectively how magnetic power can be used in various contexts. The "Magic with Magnets" set contains numerous materials, and with their help, schoolchildren can do experiments that will help them understand concepts about magnetism in the easiest way possible. The materials provided for children are: a magnetic wand, a pillar, magnetic rings, a magnet, magnetic balls, a string, brightly colored tokens, and an activity guide. This learning tool can be used by children of all ages. It can be used both at home and in formal education. At the same time, this game includes 10 activities that contribute to the development of critical thinking and the ability to observe physical phenomena. Following the experiments carried out, pupils can demonstrate that they have understood the cause-and-effect relationship.

Smart Sticks Game – S.T.E.M. Treasure Hunt from Chalk and Chuckles is another S.T.E.M. tool that is recognized for developing verbal communication skills, social skills, and critical thinking. This game contains a storage box, a lid with a specific wheel, and cards. Pupils can learn as much knowledge as possible from the fields of physics, chemistry, biology, technology, and mathematics. This game is very simple to implement. The student only has to spin that wheel to choose a color. Then, in the most alert way, choose a card according to the indicated color. On the right side of the card, there is an area to be scratched that indicates a clue about the task that is on the card. Also, on the back of the card, there is more information about the subject, more precisely, definitions or additional explanations. Therefore, the Smart Sticks Game – S.T.E.M. Treasure Hunt from Chalk and Chuckles is an educational resource that encourages pupils to develop their cognitive skills and creativity.

The S.T.E.M. Set – Pendulonium is a set specially designed for children with the aim of sparking their interest in the fields of science, technology, engineering, and mathematics. An interactive toy that combines fun with learning the principles of physics. Children receive challenges of varying degrees of difficulty to launch balls using an adjustable pendulum towards cup-shaped targets, which seems simple actually becomes a challenge that develops engineering skills, problem-solving, and critical thinking. Through this activity, children learn the concepts of force and momentum and develop their motor skills and coordination.

2.3. Ability to analyze or observe

Among the specific S.T.E.M. tools that develop the ability to analyze or observe, we can recommend S.T.E.M. – Remote-controlled Moon Model from Brainstorm, Motorized Solar SiS.T.E.M. from Educational Insights, S.T.E.M. – Discover the world through other eyes from Brainstorm, S.T.E.M. – Simple mechanisms, Remote-controlled solar SiS.T.E.M., Outer space projector, 2-in-1 projector – On a trip, GeoSafari – Fossil excavation kit, etc.

We must remember that specific S.T.E.M. tools also incorporate knowledge related to outer space. For example, the Motorized Solar System game from Educational Insights is suitable for these needs. Through this set, schoolchildren, aged between 8 and 12, assimilate information about planets in the *Solar SiS.T.E.M.*, the Sun, and the movement of the planets, respectively: rotational movement and revolutionary movement. The set contains a series of materials that allow learning to be interactive and carried out with pleasure and interest due to their complexity. A distinctive feature of this set is that it is motorized. Children understand much better how the planets rotate around the Sun, and at the same time, they can observe other celestial bodies, for example, asteroids and stars. The image of the Solar SiS.T.E.M. can be projected onto the ceiling of any room provided that it is dark.

S.T.E.M. – Discover the world through different eyes from Brainstorm is another valuable resource tool for teachers, but also for parents, which allows pupils to discover the world and the environment from different perspectives. This is designed to develop scientific learning through playful elements. This set contains: glasses, replaceable lenses, and a helpful guide that contains information necessary for the proper development of the game. Children can view the environment from the eyes of a dinosaur, an underwater fish, or other creatures. This tool encourages children's passion for science and technology, giving them the opportunity to discover the world interactively.

S.T.E.M. – Simple Mechanisms is a game covering the fields of science, technology, engineering, and mathematics. The set contains six mechanism devices and interactive cards with activities through which children can effectively understand concepts in the field of physics. Pupils can become little researchers throughout the activity, noting down the aspects they observe to better understand physical phenomena and processes. The set also contributes to the development of logical thinking, patience, and attention to detail. With the help of this S.T.E.M. set, children learn in a transdisciplinary manner.

3. Dimensions of Holistic Development through S.T.E.M. Education

The most harmonious development of a balanced and adaptable personality of the child, future adult, can be achieved by applying an integrated model of holistic development that targets at least five dimensions: cognitive, social, emotional, physical, and spiritual. This integrated approach helps to recognize and understand the complexity of child development. All dimensions are interconnected, and therefore, it is important that the education and support provided to children be in a holistic and balanced manner. In the following, we will refer to each dimension with an emphasis on how S.T.E.M. education can contribute to the development of each of them.

The cognitive dimension refers to the mental processes involved in learning: the ability to process information, to reason, to make connections between concepts, to develop critical and analytical skills, metacognitive, and to solve problems creatively. Scientific thinking is the core of the coordinated development of multidimensional ability. Thus, the cognitive dimension is distinguished by a series of important features, especially in the context of S.T.E.M. education, such as:

- *Understanding concepts* refers to the ability to learn, understand, and apply concepts from the fields of science, technology, engineering, and mathematics. This involves not only memorizing information, but also a deep understanding of it.
- *Organizing and managing information* refers to the ability to structure and organize information, as well as to use various techniques of notation and active learning.
- *Knowledge transfer* is based on the ability to apply knowledge and skills in new or different contexts, which is essential in the integration of S.T.E.M. concepts. Motivation for learning correlates with the desire to explore, learn, and understand new concepts. This influences the level of commitment and academic performance.
- *Critical thinking,* which means the ability to evaluate information, analyze arguments, and formulate logical judgments, is essential in the research and problem-solving processes.
- *Metacognition* aims to be aware of one's own thinking processes, including the ability to evaluate and control how one learns. This helps pupils adapt their learning strategies to be more effective. Evaluation and reflection are essential in the process of evaluating one's own learning and reflecting on achievements and failures, to learn from experiences and correct/improve certain elements.
- *Problem-solving* involves a process of identifying problems, formulating hypotheses, experimenting, and evaluating solutions.
- *Creative thinking* is the ability to generate original and innovative ideas, explore alternative solutions, and approach problems from different perspectives.

In S.T.E.M. education, these traits are fundamental to pupils' cognitive development, enabling them to tackle complex problems, innovate, and think critically in the face of challenges.

The social dimension of development refers to how individuals interact with others, build relationships, and integrate into communities. For a deep understanding of the social dimension, especially in the context of S.T.E.M. activities, it is essential to consider the following aspects:

- *Collaboration* refers to the ability to work effectively with others and to work in a team. The skills needed to share resources, resolve conflicts, and contribute to common goals are key elements in S.T.E.M. projects, which often require teamwork.
- *Interpersonal communication* refers to the ability to communicate effectively and interact with peers, teachers, and other members within group projects and in presenting results.
- *Negotiation and conflict resolution skills* involve the ability to manage and resolve differences of opinion and conflicts that may arise within work groups.

- *Relationship building* is related to the ability to form and maintain healthy and constructive relationships with colleagues, teachers, and community participants.
- *Social empathy* focuses on the ability to understand the perspectives and needs of others, which contributes to building stronger interpersonal relationships.
- *Developing leadership skills* involves having the skills to lead a team, motivate colleagues, and take the initiative to develop group projects.
- *Understanding diversity* involves recognizing and appreciating cultural, social, and individual differences among colleagues, which can lead to more effective collaboration and innovation.
- *Community participation* involves active involvement in group projects, events or initiatives related to S.T.E.M..
- *Social responsibility* is correlated with awareness of the impact of one's actions on others and the social environment, which can influence decisions made within S.T.E.M. activities.

These aspects, specific to the social dimension, play a determining role in the process of student integration, facilitating effective collaboration and promoting a stimulating and constructive learning environment. In the context of S.T.E.M. education, the social dimension becomes particularly relevant, given that most projects involve team activities that require constant interactions between their members.

The emotional dimension refers to aspects related to managing emotions, building interpersonal relationships, empathy, and social skills. In the context of developing S.T.E.M. skills, the emotional dimension is distinguished by a series of defining characteristics, such as:

- *Emotional intelligence* is distinguished by the ability to recognize, understand, and manage one's own emotions, as well as those of others. This is essential in group collaboration in S.T.E.M. activities.
- *Stress management* means dedicating time to learning techniques that help pupils cope with challenges and failures during STEM learning processes.
- *Empathy* involves developing the ability to understand and feel the emotions of others to build healthy and collaborative relationships in the project team.
- *Emotional self-regulation* refers to a person's ability to manage and control their emotions to respond adaptively to different situations. This involves identifying, evaluating, and modulating emotions so that they do not negatively affect thinking, behavior, and interpersonal relationships. Self-awareness helps to reflect on one’s own emotions, values, and beliefs in order to establish clear personal goals and develop a healthy identity.
- *Intrinsic motivation* cultivates a passion for learning and curiosity, an aspect that can influence S.T.E.M. performance, but is essentially related to the emotional state of pupils and the personal satisfaction they obtain from engaging in this type of activity.
- *Resilience* is the ability of an individual to cope with and adapt to adversity, stress, or trauma, and to return to a state of normality or optimal functioning after these experiences. This multidimensional capacity manifests itself in different aspects of life, including in the fields of mental health, personal development, and interpersonal relationships.

These aspects specific to the emotional dimension have a direct impact on how pupils interact in the educational environment and how they carry out their activities within S.T.E.M. projects.

The physical dimension of a child's harmonious development refers to aspects related to health, motor development, physical skills, and coordination. In the context of S.T.E.M. education, the integration of the physical dimension involves the application of knowledge and skills in practical activities, noting the following aspects:

- *Development of motor skills.* S.T.E.M. activities include manipulating materials, building models, or conducting scientific experiments that require the use of fine motor skills (such as assembling or measuring) and gross motor skills (for example, moving in space, coordination). Activities such as assembling electrical circuits, manipulating Lego pieces, or building 3D models require the use of fine motor skills. These activities help improve hand-eye coordination, an essential aspect for carrying out technical and scientific activities.
- *Practical activities.* S.T.E.M. education promotes active and experiential learning. Physical activities that involve construction or experimentation (such as building electrical circuits, engineering projects, or biology activities) help to understand scientific concepts and develop physical skills.
- *The importance of physical health.* A healthy body contributes to a healthy mind. Promoting an active lifestyle, including playing sports and exercising, helps children be able to concentrate better and develop their cognitive skills. Physical education programs that include activities such as team games can develop teamwork skills needed in S.T.E.M. projects.
- *Learning through play.* Play activities are often physical (e.g., building structures, pretend play) and develop not only scientific skills, but also a higher level of dexterity and coordination. Interactive games that involve engineering concepts (e.g., building dams to prevent floods) help to develop physical skills, such as balancing, placing elements correctly, and adapting to different physical conditions.
- *Problem Solving.* Engaging in S.T.E.M. projects can help children learn to approach physical problems, such as the stability of a structure or the efficiency of a mechanism, developing their critical thinking and practical problem-solving skills. Projects involving building a vehicle from recycled materials require critical thinking to solve practical problems related to stability, weight, and efficiency. Children must experiment and adapt prototypes, thus also developing the physical skills needed to manipulate materials.
- *Collaboration and Socialization.* S.T.E.M. projects often involve teamwork, which develops not only social skills but also physical skills by coordinating and collaborating in practical activities. Group projects, in which pupils present a project on renewable energy or build a robot, encourage physical interaction and communication, elements that are essential for developing social skills and completing technical tasks.
- *Using technology.* Many S.T.E.M. activities involve the use of technology (such as drones, robots, or lab equipment) that require physical integrity and good coordination. Lab activities that involve the use of technological equipment (for example, 3D printers or robotics kits) require not only physical qualities but also technical knowledge. Handling these tools helps develop physical coordination and dexterity.

Therefore, the physical dimension can contribute to a harmonious and holistic development of children, helping children develop the skills necessary to address real-life challenges, while improving their health and physical coordination.

For the holistic development of children, integrating the spiritual dimension into S.T.E.M. education involves not only the development of technical skills but also the formation of individuals who think critically, act ethically, and contribute positively to society. When we analyze *the spiritual dimension*, we observe several key characteristics that differentiate it from the other dimensions in the context of developing S.T.E.M. competencies:

- *Existential questions.* Educating children in the Socratic spirit to develop critical thinking on moral values is essential for personal and ethical development. By carrying out S.T.E.M. activities, the teacher can encourage the student to ask deeper questions

about the nature of existence, the universe, and man's place in it. These questions can stimulate philosophical and spiritual reflection, even within technical subjects.

- *Values of humanity.* Integrating global issues into the curriculum, such as climate change, social inequalities, or public health issues, can stimulate discussions about fundamental values and beliefs, which are linked to the spiritual dimension.
- *Ethics and responsibility.* Pupils can be encouraged to become aware of the ethical implications of research and innovation and to develop solutions that promote a deep understanding of ethical values and social responsibility. For example, within S.T.E.M. education, one can learn about the impact of technologies on the environment and society.
- *Curiosity, openness, and mental flexibility.* The spiritual dimension encourages exploration and the search for meaning. S.T.E.M. education can encourage scientific curiosity about the world, promoting exploration and continuous learning that can also be linked to deeper questions about our place in the universe.
- *Empathy.* The spiritual dimension can develop empathy, which is essential in designing technologies and solutions that meet the diverse needs of people.
- *Interconnectivity.* A reconciliation between science and spirituality can lead to a recognition of the interconnectedness of all life forms, promoting sustainable solutions to current world problems, such as climate change.
- *Interdisciplinarity.* Integrating art, science, and the humanities into S.T.E.M. projects can bring a spiritual dimension. For example, projects involving biology and art can explore the beauty of nature and cultivate an appreciation for life.
- *Collaboration and community.* S.T.E.M. activities that promote teamwork and community involvement help develop a sense of community and interconnectedness, and develop empathy and compassion, values important in the spiritual dimension. Spiritual values can encourage collaboration across S.T.E.M. disciplines. and diverse communities, facilitating inter- and transdisciplinary projects that respond to social needs.
- *Reflection and self-assessment.* Learning through S.T.E.M. activities can stimulate critical thinking, and discussions about values, goals, and meaning can help pupils shape a deeper personal vision. This process of reflection can help them connect their scientific knowledge with existential questions. Reflective practices can help individuals evaluate the impact of their S.T.E.M. work and adjust their approaches according to personal values and the common good.
- *Value-based innovation.* Approaches grounded in spiritual principles can lead to innovations that not only solve technical problems but also improve the quality of life, respecting human dignity.
- *Resilience and adaptability.* Through S.T.E.M. activities, pupils can learn about failure and success, thus developing a resilient attitude. This can strengthen their personal beliefs and values, contributing to healthy spiritual development.
- *Mindfulness.* Mindfulness techniques, which are increasingly popular in education, can be integrated into S.T.E.M. activities to help pupils focus, be present, and develop an appreciation for the present moment, an important aspect of spiritual development.

Thus, the spiritual dimension can be integrated into S.T.E.M. education not only through innovation and technology, but also through interactions that contribute to a deeper understanding of self, others, and human existence.

Conclusions

EU, OECD, and UNESCO policies underline the importance of skills for career advancement, life satisfaction, and sustainable economic competitiveness, as a central principle of

the European Skills Agenda. Due to rapid transformations caused by digitalization and global crises, people from different educational backgrounds must develop and adapt their skills to face future challenges in the labor market. Teachers of young children must have consistent academic training to develop children's S.T.E.M. skills. The questions that can generate possible answers to the problem presented can have the following starting points: analysis of learning contexts, current practices, and teaching resources for the development of key skills; the relationship between skills and teaching innovation; and the need, respectively, for the level of professional development of teachers for the development of S.T.E.M. skills. The integration of key competencies, STEM teaching tools, and a holistic approach in primary education is essential to develop well-prepared students, capable of solving complex problems and collaborating effectively in contemporary society, thus promoting sustainable learning that is adaptable to the rapidly changing world.

The next decade will play a key role in defining new paradigms of work and education in the 21st century, especially through the lens of STEM (Science, Technology, Engineering, and Mathematics) skills. In this context, STEM skills will become fundamental for understanding and using the various digital tools that are transforming industries and ways of working. From process automation, data analysis, and programming to the use of artificial intelligence and emerging technologies, STEM skills will allow individuals to adapt quickly and effectively to changes in the labor market. In addition, education focused on STEM skills will need to reinvent itself, with the integration of digital technologies into the curriculum becoming essential for the preparation of future professionals. Thus, students will have the opportunity to develop not only theoretical knowledge, but also practical skills that will facilitate collaboration and innovation in digitalized work environments. Therefore, investing in STEM skills training will contribute not only to the individual development of employees but also to increasing the economic competitiveness of societies, ensuring their ability to face emerging challenges and opportunities.

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