GUIDELINES FOR FAMILIES

Tips to encourage the participation of children in STEM activities

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Content

Introduction

The document presented here intends to share with families some guidelines on the STEM approach, its application and those points that can be worked on from the family environment, generated from the experience acquired during the activities of the botSTEM project.

This document does not want to be a guide on the approach, but rather tries to answer those questions that families, who want to enhance the scientific-technological competencies of their children, may ask themselves when addressing this approach from the domestic point of view. We emphasize that the activities proposed in the project (https://www.botstem.eu/es/) can be carried out at home for this empowerment.

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What does STEM mean and why use it?

In recent years we have been bombarded with the acronym STEM. We can see the use of this acronym in games and toys, books, extracurricular activities or educational offers for our children, and even for ourselves. But what does it mean? STEM is the acronym for Science, Technology, Engineering and Mathematics, an acronym to which the “A” for Art (STEAM) was later added.

The STEM approach goes beyond the conceptual learning of the disciplines, it deepens in the acquisition of competencies and skills to solve real problems.

Sometimes it is explained that this approach was born with the main objective of training qualified personnel to meet the needs demanded by the employment sectors that are developing the fastest today, articulating the professionals or STEM profiles. But when it comes to education we have to deepen and talk about an approach with which the integration of the different disciplines is intentionally achieved, in such a way that it contributes to achieving a scientific-technological literacy and with it the acquisition of the necessary skills to address and solve the problems of our society. This implies the approach of the different disciplines transversally, in this way, in addition to the acquisition of concepts, significant and contextualized learning is generated.

But,
where is robotics and programming?

It can be seen in some robotics games and kits, in the robots themselves or in the offer of robotics extracurricular activities classified as "STREM", which emphasize the "R" of robotics that would be worked from a STEM approach. However, including robotics or programming is not enough to achieve this integrative approach. As it is described in the botSTEM project outputs, robotics encompasses science and technology in an interdisciplinary way, where different areas of engineering come into play (mechanics, engineering, informatics…).

Computational thinking is closely related to programming and robotics. It involves the understanding of analytical thinking, which becomes a valuable tool to acquire the logical thinking necessary to help solve problems. However, it is important to create an environment in which problem solving, initiative and creativity are encouraged, not wanting them to act as automatons for programming or handling a robot, but rather to integrate and work in an interdisciplinary way with other areas.

Robotics is part of engineering and must be integrated by working in an interdisciplinary way the different areas.

This is very well understood if we take an example with the area of mathematics. Different activities can be carried out with children that promote learning about this area: mental calculation or mathematical problem solving, and even in a manipulative way through different materials. However, in this way we are not working from an interdisciplinary approach. But if we now propose an investigation on the appropriate conditions for the germination of a seed, apart from working on scientific aspects, in the representation of the data they are counting the germinated seeds (add), compared to the non-germinated (subtract), they can construct graphs with the results (for example, using the number bars) or even carry out simple statistical analyzes depending on the level at which the proposal is made.

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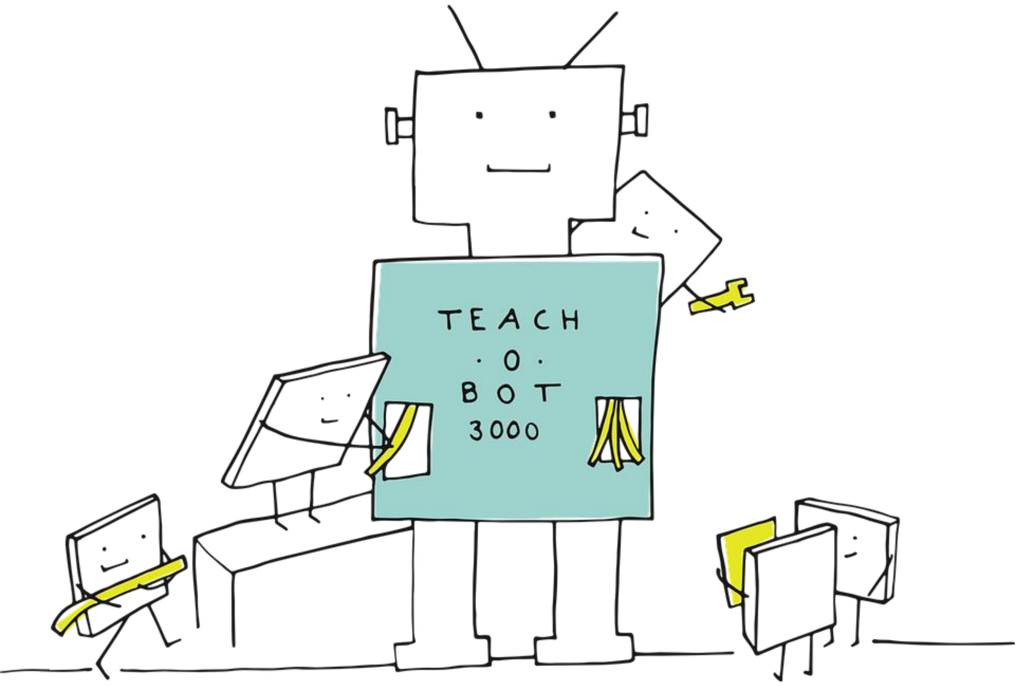
Some practical guidelines for families

1. How is the STEM approach applied?

The integrated STEM approach allows the connection of scientific concepts with real-life situations, in which manipulative activities take on vital importance. For this, children must be actively involved in solving the problems raised, while acquiring their autonomy to solve them. Two methodologies are proposed in the botSTEM project activities: inquiry and engineering design. The first one refers to the different ways that scientists study the natural world to create knowledge; and in the second one, problems are analyze and solve by applying knowledge and technology, generating new designs or improving existing ones as is done in the engineering field.

But then, when children are conducting an experiment, are they applying the STEM approach? In order to answer this question, we have to distinguish four different situations: a situation in which children only play, with no clear objective; a situation in which they only observe what another does; a situation in which children are following a recipe to reproduce an experiment; and finally a situation in which children are carrying out an activity as intended with the STEM approach.

It is intended to achieve significant learning, promoting manipulation, but differentiating it from simple manipulation, demonstration or reproduction of experiments as a recipe.



For example, children may be playing with oil and water in the kitchen and observe that the oil “floats” on the water, without leading to any meaningful learning. In the second type of situations, families show how the oil always stays on top of the water, regardless of the order of placement or the quantity. In this case, children observe an effect; and by not relating to concepts, in many cases they see it as "a magic trick". In the third case, we may give them an instruction sheet or a video, in which they are instructed to have three different liquids (water, alcohol and oil) in a glass, to observe that one floats on top of the other. In this case, the research results show that children do not evaluate these activities as significant and tend to bore them, because they do not play an active role in solving the problem. Finally, we can ask them to find out why oil stains in the sea remain on the surface, even though the oil seems heavier.

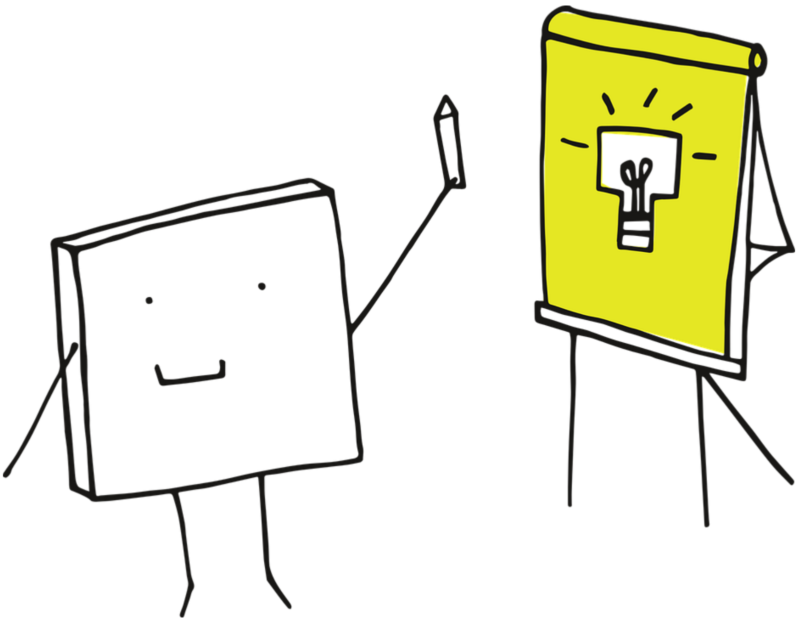
Children can propose an experimental design considering different possibilities (variables in technical language), for example, measuring the mass of each liquid in a given volume; observing and recording the results of the experimentation to be able to calculate the density; and drawing conclusions that allow them to answer the initial question, as stated in the inquiry methodology. In this situation, they build meaningful learning around the concept of density, managing to understand the phenomenon, “it's no longer magic, it's science!”

2. What kind of problems can be raised?

The problem-situation has to be significant for children, in order to capture their interest. However, to get children motivated it is convenient to offer contextualized situations related to everyday problems, real life events or close to them. It is important to adapt the difficulty of the activity to their level, both knowledge and skills, allowing them to put into practice what they know and explore new knowledge, at the same time that it allows addressing the different disciplines.

For example, you can ask them to solve the following question: Why did the chocolate in my sandwich melt inside my backpack on a hot day? This question allows to address the forms of heat propagation, or to propose the construction of a system that conserves the cold to work on insulating and heat conducting materials.

The problems raised must be close to kids and they must transform them into the main actors and actresses, cover different disciplines and be approachable by children, both due to their conceptual and manipulative difficulty, so we must adapt them to their age, capacity and abilities.

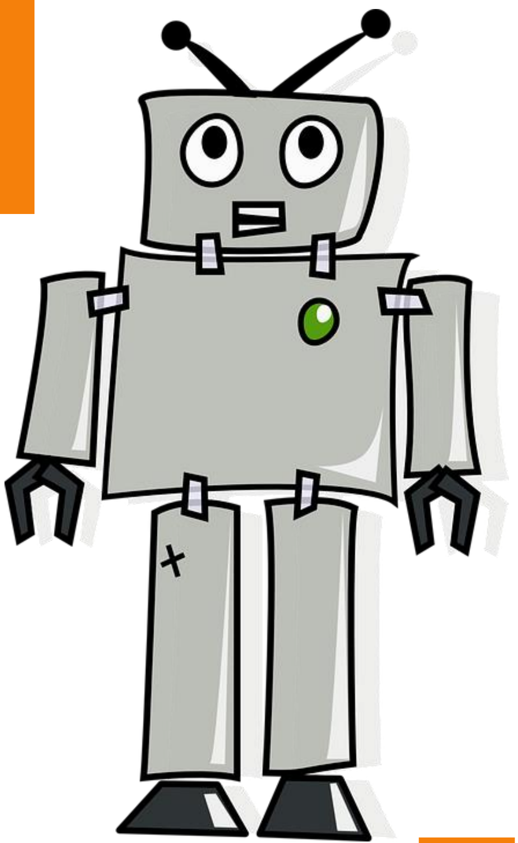


3. What age is appropriate to use the STEM approach?

On many occasions, this approach is proposed with students from 8 years of age, giving more importance to this work from the age of twelve because it is considered that at this age they have already acquired knowledge about the subjects and have more capacity to make decisions. However, since a girl or a boy begins to discover and learn, they are already solving problems and learning from situations in their close environment. When they use a bottle, cutlery or when they investigate how a toy works, they use all their senses, nourishing themselves from the experiences they have lived in other learning experiences.

From this moment, children are acquiring the ability to ask themselves questions and with it the need to solve them. Studies developed within the botSTEM project further show that the integrated STEM approach can be carried out using inquiry methodology and engineering design, including educational programming and robotics, from the age of 4 .

The research carried out in the botSTEM project supports that the STEM approach can be applied with integrated educational programming and robotics using the proposed methodologies with children from 4 years old, which helps them develop language and communication skills, creativity, reasoning and problem solving.

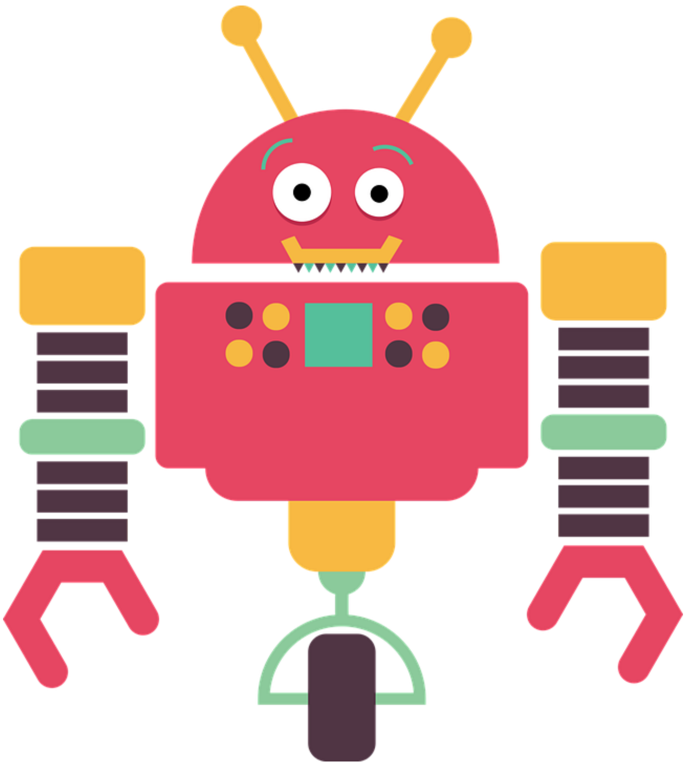


4. Play with a robot or learn by playing with a robot.

Operating a remote controlled robot does not involve significant learning. It is proposed to work in such a way that robotics is a tool within educational problem-solving contexts.

Many families wonder which robot is the ideal for learning robotics and which tool is the best for learning programming. Currently, in the market there are many types, formats of robots and platforms aimed at different ages that promote the learning of programming and robotics.

However, what is relevant is not the type of robot or platform itself, the most important thing is that these tools are integrated into an educational problem-solving context, being able to work also in an interdisciplinary way with other areas within a STEM approach, as has been proposed in the botSTEM project.



For example, if we provide them with different materials, they can be asked to build a ramp on which a robot has to climb to a certain height. In this case, although they are giving instructions to the robot to go up the ramp, and therefore programming is being put into practice, this is a part of an entire process.

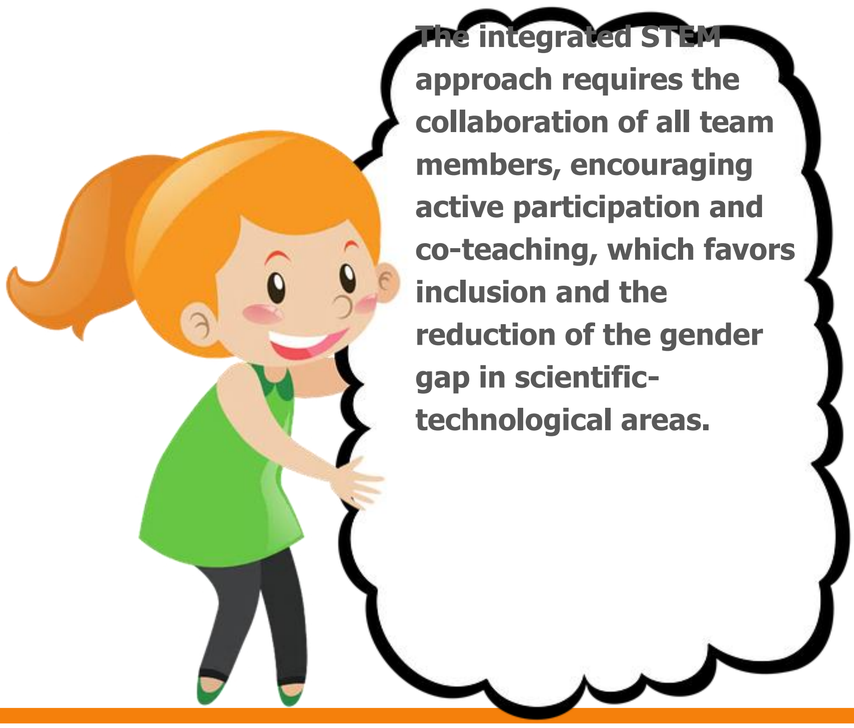
The children go from playing with the robot, to using it as a tool to check their prototype ramp. Another example of this approach can be making a prototype of a system that provides different types of plants with optimal humidity conditions.

After analysing the needs of each plant (type of plant, need for humidity, characteristics...) they can automate different devices that, previously programmed, can supply the desired humidity to the plants.

5. But, are all children prepared to handle activities from this approach?

Expertise begins with practice. This is something we know from our own experience. You cannot learn to read if no one tells you, at least, how each phoneme sounds. And you learn in steps, you must recognize the spellings, phonemes, syllables and words... to finish understanding what has been read. In the same way, it is not correct to think that the STEM approach is only for those children who have more developed scientific or mathematical competences. The botSTEM project proposes an integrated STEM approach using a proposal for collaboration between the group's components, as well as with the referents who act as a guide in the proposed activity. In this way, joint participation is encouraged throughout the process, giving importance to all the contributions and actions made by each team member working as equals and promoting co-teaching. It should be noted that numerous investigations indicate that from problems close to children, using the manipulative methodologies indicated above, a truly inclusive teaching of science and technology is allowed.

Although it is essential to adapt the proposed activities to the needs and interests of children, it is also essential that all them are active participants, spending more time interacting and less memorizing, which favors an "apprehension" of the concepts from manipulation and direct experimentation, fundamental basis for a later more abstract conceptual development.



6. Making mistakes is human, rectifying wise.

This phrase derives from the original Latin: "*Errare humanum est*", and it indicates that the mistakes that humans make have to be accepted and from which they have to learn. This same phrase can be used in the learning process. It is not necessary to instill fear of making mistakes in children; this fear is one of the sources of anxiety that often prevents them from being creative, making decisions, questioning proposals or even expressing their own.

The methodologies proposed in the botSTEM project start from the transformation of the error into a useful tool for solving problems, favoring that children themselves build knowledge. For example, when an engineer is looking for a solution to a real problem, it is very likely that he or she will not find the correct solution the first time, and it is even likely that there is not only one solution, but several: proposals are planned, prototypes are made and tests are carried out to improve or solve the errors. This becomes an opportunity to learn well from the concepts that were not understood or correctly applied.

For this reason, we must not allow children to become frustrated in this process, which, on the other hand, should not be avoided. Thus, in situations where frustration appears, help them to reflect on the causes of the error; accompany them in the process and not solve their problems, in order to avoid the abandonment and demotivation that are often related to science and technology.

The error is an opportunity to learn and consolidate concepts, but we must not let it lead to excessive frustration and demotivation towards these areas.

7. Beyond the acquisition of STEM concepts and skills.

In addition to the acquisition of concepts and competencies related to the areas of science, technology, engineering and mathematics, the STEM approach, according to the didactic model proposed by the botSTEM project, provides children with the development of other skills, such as for example:

- Collaborative work, which implies an action of respect towards others, since the ideas and proposals of colleagues must be respected, as well as speaking turns.
- Decision-making, because they have to justify their proposals and defend ideas, either proposed by them or by their teammates.
- Psychomotor skills, through manipulative activities, experimentation and prototype design.
- Language development, by exposing and defending their ideas and explaining their results and conclusions.
- Creativity, sharing knowledge and ideas.
- Self-esteem and confidence when developing their ideas, since they realize that they have the ability to solve problems and learn from mistakes.
- Emotional management when facing frustration.

8. What can we do from the family?

After all the process carried out in the botSTEM project, it has been seen that activities can be developed under a STEM approach from childhood. From families we must take advantage of the curiosity of our kids to promote the development of competencies and positive attitudes in these areas.

It is **not** necessary to buy robotics or science kits, experiment books or have a STEM career to be able to promote an affinity for STEM areas in girls and boys from the family.

Here are some guidelines that can help to work on this approach from families and promote scientific-technological vocations from childhood:

- Encourage children to notice their environment, explore it, and ask questions.
- Encourage them to search for solutions to their own questions; do not give them the answer.
- Help them focus the questions so that they can be investigated taking into account their age and using the 'what' and 'how'.
- Listen and encourage children to explain their ideas, proposals and reflections.
- Help children understand the error as an element of the learning process.
- Avoid frustration by accompanying them in reflection.
- Do not pose problems that they cannot solve.
- Take into account the manipulative and motor skills they have.
- Generate pleasant moments that encourage motivation and not rejection.
- Boost their confidence and value their effort.

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