



## **Is STEM Classroom the Appropriate Learning Environment Where Students Can Achieve Their Learning Objectives?**

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### **Abstract**

The Fourth Industrial Revolution (Industry 4.0) has brought transformative changes to daily life, necessitating adaptations in educational systems to meet new technological and societal demands. This article explores STEM (Science, Technology, Engineering, and Mathematics) education as a viable approach to equipping students with essential 21st-century skills, focusing on the learning environment's role in achieving these goals. Through documentary research, the study analyzes the key components of an effective learning environment—organization and classroom dynamics—and evaluates whether STEM classrooms fulfill these criteria. Findings suggest that STEM education fosters flexibility, interdisciplinary problem-solving, collaboration, and creativity, aligning with the principles of an optimal learning environment. The teacher's role shifts to that of a facilitator, guiding students through inquiry-based learning while promoting motivation, communication, and critical thinking. The study concludes that



STEM classrooms provide a conducive setting for developing the skills needed in an evolving workforce, supported by pedagogical strategies that emphasize real-world applications and student-centered learning.

**Keywords:** STEM education, learning environment, 21st-century skills, Industry 4.0, interdisciplinary learning, collaborative learning

## **Introduction**

The Industrial Revolution 4.0. is the one that brings changes in our daily life, educational systems are called to adapt to these changes (Guzmán, Muschard, Gerolamo, Kohl, & Rozenfeld, 2020; Gonzalez-Perez & Ramirez-Montoya, 2022; Unesco & Boon, 2019; Sony & Mekoth, 2022; Athan & Thacha, 2022), which are multidimensional. Artificial intelligence, machine learning, algorithms (Gonzalez-Perez & Ramirez-Montoya, 2022), learning networks (LNs), virtual learning communities (VLCs) (Tsolaki & Stathopoulou, 2023) are just some of the technological changes that need to be integrated into new learning environments.

This article proposes STEM (Science Technology Engineering Mathematics) education as a possible solution that, on the one hand, can meet the challenges of the environment and, on the other hand, can equip students with appropriate 21st century skills. These skills are at the heart of STEM education and are essential to enable tomorrow's professionals to meet the demands of their working environment. This article examines the learning environment component. More specifically, it examines the appropriate conditions that must be present in a classroom in order for students to achieve their learning goals. It then examines whether a STEM classroom is an appropriate environment for the student to achieve the desired goals.

## **Methodology**

The method used to write the article was documentary research. Google Scholar, Semantic Scholar databases were searched for articles. The following complex search was performed on these machines (STEM Education) AND (Classroom) AND (Learning Environment).

## **General principles of an appropriate learning environment.**

The learning environment has four components: infrastructure, organization, learning environment and staff culture. Infrastructure refers to the buildings, technological and material resources available in an institution; organization refers to the teaching and curriculum. The learning environment relates to the acquisition of knowledge, motivation and the classroom climate. Staff culture refers to the views of teachers (Gislason, 2010). This article focuses on the components of organization and learning environment.

In terms of organization, creating a suitable learning environment requires that the teacher is given freedom of movement by the curriculum itself (Hernández-Torrano & Ibrayeva, 2020). In this way the teacher can make flexible use of his/her space, materials and the time available to teach the course (Hernández-Torrano & Ibrayeva, 2020). This flexibility, combined with the use of outdoor spaces, collaboration with people beyond the pupils and a sense of respect, can stimulate pupils' creativity (Hernández-Torrano & Ibrayeva, 2020). Freedom from the curriculum also allows teachers to choose the teaching method that suits their classroom, the



level of their students and the learning objectives they have set (Thornhill- Miller, και συν., 2023).

The teacher at classroom level is a leading figure who is there to guide his/her students to achieve the desired learning goals (Petre, 2020). His main role is to guide and encourage his pupils throughout the lesson. The teacher organizes the thinking of his/her students to achieve the desired goals (Bryce & Withers, 2003); in the same direction, he/she creates positive interpersonal relationships in the classroom (Yang, Deng, & Wang, 2023), where the free expression of many different ideas and thoughts (Guzmán, Muschard, Gerolamo, Kohl, & Rozenfeld, 2020) (Petre, 2020) (Wu & Wu, 2020), (Anderson, et al., 2022) (Perera, 2022) is encouraged; and the exploration of each of them as a possible answer to the question posed. The possibility of finding alternatives (Ellerton & Kelly, 2021), i.e. the encouragement of divergent thinking (Lasky & Yoon, 2020), requires the marginalization of pre-existing views that might impose any kind of restriction on the way of thinking. Such views are associated with racial and racist discrimination.

In addition, a positive climate can be created through unrestricted communication between teacher and pupils and between pupils (Petre, 2020). The teacher, through genuine interest in his pupils (Andreu, Sweet, & Carter, 2020) and through active listening (Guzmán, Muschard, Gerolamo, Kohl, & Rozenfeld, 2020), helps to improve not only their communication skills but also their cooperation skills (Guzmán, Muschard, Gerolamo, Kohl, & Rozenfeld, 2020). At the same time, the teacher does everything possible to ensure cohesion among the pupils in the class (Petre, 2020). In any case, classroom rules must be clearly stated and the teacher is there to ensure that they are respected (Petre, 2020; Warren, 2021).

At the level of the classroom, the teacher guides and corrects his pupils in order to achieve the production of new knowledge and also to become an extension of their ideas (Wu & Wu, 2020). In doing so, he adapts his teaching, the educational methods he chooses, the learning objectives and the tasks he assigns to his students to their abilities (Lasky & Yoon, 2020) and interests [21]. An appropriate educational method to achieve these goals is individualized teaching (Saidovna, 2022). During the course of the lesson, the teacher should identify and address the cognitive deficits that his students may have (Warren, 2021).

Another component that can improve students' mastery of knowledge is the acquisition of motivation. Motivation is the learner's orientation towards a goal (Pohan, Asmin, & Menanti, 2020) and is directly related to the acquisition of interest in the subject matter (Pasigon, 2022). The development of motivation is based on three sub-disciplines:

- The acquisition of interest
- The acquisition of autonomy
- The acquisition of a sense of belonging (Cubillos, Roncagliolo, & Cabrera-Paniagua, 2023).

When students are motivated, they are activated and they themselves acquire the desire to conquer the learning objectives set.

It is clear that motivation is fundamental to the learning process. The teacher, as the one who guides, is also the one who has to motivate his students to be interested in the topics related to



his course (Cubillos, Roncagliolo, & Cabrera-Paniagua, 2023). This goal can be achieved through the presence of feedback, rewards and direct communication during the lesson. Instilling in students the belief that they can do well can also have a positive effect (Warren, 2021). A belief that is well founded and linked to detailed lesson planning. In this way, students acquire a positive attitude towards the lesson (Pasigon, 2022), as they are pushed to reach the end of the activity they have been given (Pohan, Asmin, & Menanti, 2020). The presence of motivation leads to the activation of students in the classroom, with positive results in terms of their performance (Pohan, Asmin, & Menanti, 2020). According to self-determination theory, intrinsic motivation is created, which develops students' desire to explore (Cubillos, Roncagliolo, & Cabrera-Paniagua, 2023). Through motivation, the learner has an innate desire to achieve the desired educational goal by deriving satisfaction from the knowledge-skills acquired at the end of the process (Cubillos, Roncagliolo, & Cabrera-Paniagua, 2023). The teacher on his part through feedback, rewards and direct communication with class members can greatly enhance motivation (Cubillos, Roncagliolo, & Cabrera-Paniagua, 2023).

In addition, the teacher should present the lesson in an attractive way (Warren, 2021). This includes the use of new technologies and digital tools (Meirbekov, Maslova, & Gallyamova, 2022). With the right stimulus, ICT can enable students to carry out their own independent research (Tsolaki & Stathopoulou, 2023).

### **Stem Classroom**

In a STEM classroom, the main learning objective is the acquisition of 21st century skills (Seevaratnam, Gannaway, & Lodge, 2023) (Lin, Yeh, Hsu, & et al., 2023) (Gonzalez-Perez & Ramirez-Montoya, 2022) (Tytler, Aderson, & Li, 2020) (Thibaut, et al., 2018). 21st century skills are those that a worker needs to be able to cope with the competitive and constantly evolving environment defined by the Industrial Revolution 4.0. (Gonzalez-Perez & Ramirez-Montoya, 2022) (van Laar, van Deursen, van Dijk, & de Haan, 2020) (Liebech-Lie & Sjølie, 2020). However, there is no precise definition or number of them [30]. Modern curricula focus on creating the personality of the active citizen of the 21st century and are aligned with the demands of the labor market (McLennan, 2021).

It is now accepted that 21st century skills can be acquired by any individual as long as they receive the appropriate education. Clearly, it is the educational environment that should provide students with these opportunities. More specifically, creativity (OECD, 2019), (Lasky & Yoon, 2020), (Thornhill- Miller, και συν., 2023), critical thinking (Orhan & Çeviker Ay, 2023), (Alsaleh, 2020), collaboration (Petre, 2020; Valtonen, και συν., 2021) are some of the skills that are developed in individuals through the education they receive.

The main objective of a STEM lesson is to solve a problem from everyday life using knowledge from the different fields, i.e. different sciences (Oon-Seng, 2023) (Thibaut, et al., 2018) (Lin, Yeh, Hsu, & et al., 2023) (Maass, Geiger, Ariza, & et.al., 2019). The lesson can be taught either by one teacher, who should have knowledge from all fields, or by a group of teachers from different disciplines, who work together to deliver the lesson (El Nagdi, Leammukda, & Roehrig, 2018; Vieira, Tenreiro-Vieira, Bem-Haja, & Lucas, 2023). In the second case, the workload for each teacher is reduced, but better organization and excellent cooperation



between teachers is required (El Nagdi, Leammukda, & Roehrig, 2018). It is worth noting that in many cases the construction of a mechanical analogue is a necessary prerequisite in a STEM classroom (Gao, Li, Shen, & et al., 2020) (Margot & Kettler, 2019). The approach to the problem is always interdisciplinary (Leung, 2020) (Maass, Geiger, Ariza, & et.al., 2019) (Lin, Yeh, Hsu, & et al., 2023) (Tytler, Aderson, & Li, 2020).

The problem to be solved by the students must be clearly defined and allow more than one correct solution. Then the appropriate pedagogical method is chosen to enable the students to investigate. Such methods are collaborative (Pohan, Asmin, & Menanti, 2020), (Thibaut, et al., 2018) which create positive attitudes of students towards the subject (Petre, 2020; Warren, 2021). These positive attitudes will contribute even more to the students pursuing a professional career in the STEM fields (Lian, Tsang, & Zhang, 2021), thus meeting the ever-increasing demand for workers in these fields (McDonald, 2016). After collecting information, students process it, evaluate it and use it to find solutions. From the solutions they find, they are asked to select the one they consider the best (Golegou, Wallace, & Peppas, 2024). Selection criteria include sustainability, ethics and humanity (Gonzalez-Perez & Ramirez-Montoya, 2022).

It creates the appropriate environment for students to solve a problem that is not so clear, thus enabling students to acquire deeper knowledge about the issue (Margot & Kettler, 2019).

## **Discussion**

The data obtained from the international bibliography on the characteristics of an appropriate learning environment and a STEM classroom are then compared to see if the latter has them. First of all, a STEM classroom gives the teacher the freedom to choose the problem to be posed to his students in terms of its complexity and the materials needed to solve it. It also gives him the opportunity to choose between different teaching methods, depending on the level of his class and the time available.

The teacher in a STEM classroom takes on the role of a guide. He has planned the problem in detail, has presented it clearly to his students, has clear objectives. Throughout the educational process, he is there to support and advise his students, but not to give them a ready-made solution. At the same time, throughout the process, he encourages his students to express themselves freely. He encourages them to ask questions and express their opinions about the solution to each stage of the problem. From the free expression of ideas, many different ideas are expected to emerge, so that in the end the one that is characterized by innovation and creativity is chosen. In order for students to find the right solution, they have to discuss with each other, so they need to communicate and work together.

When solving a problem, it is important to carry out research, both when analyzing the data and in the process of solving the problem. Students will be faced with unknown situations in which they will have to find a solution, in many cases their choice may not be correct, so they will have to check if there is another solution or if they have already found an alternative.

As far as communication is concerned, it is a key component of STEM teaching, since most of the pedagogical methods used require students to work in groups. In these groups, students





from different backgrounds are working towards the same goal, so they need to find a way to work together.

Finally, in terms of motivation, students' involvement in a problem of everyday life is in itself motivating and increases their interest both in the lesson and in achieving the ultimate educational goals.

## **Conclusion**

As can be seen, a STEM classroom has all the characteristics of a learning environment suitable for the development of students' skills and the achievement of their educational goals. Because

- It gives the teacher freedom in the way the lesson is conducted,
- it allows the teacher to remain a guide for his students and not just a transmitter of information to them
- the conditions are right for students to express their questions and thoughts
- It requires research to be carried out.
- It encourages the testing of more than one solution in order to choose the best one.
- During the process, students communicate with each other and with the teacher.
- The link between the problem and everyday life motivates students to engage with the different areas.

It is clear that a STEM classroom has all the characteristics needed in modern education to be a learning environment that meets the demands and challenges of the 21st century.

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