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Traits of STEM Teachers for 21st Century STEM Education

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Article

Traits of STEM Teachers for 21st Century STEM Education

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Abstract: STEM education is a growing global trend, but what are the essential characteristics that should be cultivated in the curricula of the higher education institutions that teachers attend, as well as through the training programmes they follow throughout their careers? This literature review aims to identify the characteristics that a STEM educator should possess in order to achieve the goals of such education. Beyond basic pedagogical knowledge, educators themselves need to acquire 21st century skills. As mentors, they are responsible for setting a positive example for their students. A STEM classroom is characterised by democratic principles and the desire to find innovative solutions. The teacher is the intermediary between the goals of the educational system and their achievement. It is therefore essential to study the aspects of their training that can contribute to this direction.

Keywords: STEM Education; secondary education; teacher skills; 21st century skills

Introduction

Education is the process by which people develop the capacity to learn [1]. In the school environment, this process is achieved through the transmission of information from teacher to student [2]. The aims of education are constantly changing, adapting to the new conditions of each era. As a result, the skills that a teacher needs to have in order to contribute to the achievement of these goals through teaching are also changing [3]. Despite the changing goals [4], today's education must provide students not only with knowledge, but also with skills that will help them cope with everyday life as adults [4, 5].

Humanistic education aims to instil ethics in every decision an individual makes and to foster the habit of thinking before acting [6]. The education an individual receives is responsible for protecting societal well-being by providing knowledge and skills to face an uncertain future [4]. In particular, the skills expected to be acquired during schooling are 21st century skills. In addition, it is essential that students embrace values such as sustainability. STEM education offers a proposal that combines the acquisition of both skills and values [7, 8].

Teachers in the 21st century will need to be multi-skilled in order to pass on these skills to their students [9]. In their daily work, they will have to manage situations, observe their pupils and organise the whole educational process [10]. Teachers are responsible for teaching, i.e. transmitting knowledge to students [2]. They have the task of analysing the classroom conditions and selecting appropriate teaching methods to achieve the desired goal [8]. For students to acquire the necessary skills, teachers must first develop these skills themselves [11, 12] and then pass them on through interaction and communication with their students [13].

In this challenging environment, teachers need the right tools, including knowledge of appropriate teaching methods, to be successful [9]. First, they need to identify the desired skills and then choose ways to develop them through different subjects [4]. In other words, the goal needs to be set first, followed by the teacher's strategy.

Schools can influence students' development on several levels, such as cognitive skills, knowledge, experience in a specific field, willingness to cooperate and trust others, persistence in goals and not giving up at the first difficulty [14].

Teachers are moral role models and mentors for their students [3, 15], leading by example through their actions and behaviour [2]. In this way, teachers, as role models, can inspire pupils to imitate them [2]. They also shape the development of students' skills [2] and guide them to high achievement through their ability to manage the classroom [13]. With in-depth knowledge of the subjects they teach, teachers can improve their students' understanding [16].

Furthermore, Wang and Jia (2023) mention the view of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) that the teacher is not only in the classroom to impart knowledge, but also to encourage thinking and promote the exchange of ideas [17]. The teacher supports students when necessary, guiding them to become independent and able to communicate effectively with group members [1], initially within the classroom and later in their adult lives with colleagues. In this direction, pedagogical programmes should focus on the teaching of STEM education [18].

The role of the teacher is crucial in an ever-changing environment dictated by technological advances, climate change, refugee flows, globalisation and other factors. The purpose of this research is to fill the gap in the international literature by identifying the basic competencies and skills that a teacher needs to implement STEM education, as well as the ways in which they can foster these skills in their students. Proper teacher preparation is a key factor in the subsequent success of the education system and the goals that students can achieve [16].

In addition, an effective teacher needs to have practical knowledge in a particular subject area [18]. These are also reasons why governments seek to improve teacher education programmes [16]. In addition, studies conducted in Istanbul, Saudi Arabia, Greece and China [19, 20, 21, 22, 23] show that teachers themselves do not feel confident in implementing STEM education. Despite the growing global interest in STEM education, there is a noticeable lack of practical frameworks and educational goals [18]. These findings highlight the importance of this research as it can guide educators on the skills required and help them to understand that STEM education can be accessible to all teachers. This article can therefore serve as a basis for the training of STEM educators. First, it refers to the general skills that every teacher should have, whether or not they use STEM education. It then looks at the demands that this type of education places on the teacher and the design of the lesson. Finally, it discusses how teachers can contribute to the development of some of the basic 21st century skills in their students.

Key questions to be answered at the end of the research are:

1. How should the STEM teacher organise his/her classroom to contribute to the best possible learning outcomes?
2. How can the development of 21st century skills be promoted through STEM teaching?

General teachers' knowledge.

A teacher's knowledge can be divided into four components, each of which plays an important role in achieving the final goal. These four components are

- assessment
- pedagogy
- curriculum
- about students [24].

With every change in the educational system [3], but also with the evolution brought about by the passage of time [17], teachers are the first to be called upon to adapt. In the future, education systems are expected to face changes [18, 25] such as societies with a high average age, increased migration, technological development and a changing labour market [25]. Such an environment is full of challenges and constantly new and unknown conditions that future professionals will need to

be able to cope with. Students and future active citizens should therefore be equipped with skills that will enable them to cope with any difficulties in these ever-changing conditions [26]. To achieve this ambitious goal, teachers will have to adapt both their knowledge and the pedagogical methods they use [3]. It is globalisation, combined with the digitalisation of many processes of everyday life, that requires all teachers in the world to acquire the same skills [8].

It is clear that in modern society, the skills that a teacher must have are not only related to the cognitive aspect, but also to the social aspect. In order to increase his/her effectiveness, a teacher must cultivate interpersonal relationships with the people he/she will have to interact with in his/her professional environment [27].

General principles of appropriate learning environments

As with any type of education, STEM is largely delivered in a formal classroom learning environment. Therefore, the successful implementation of STEM education is first of all governed by general principles that are worth mentioning because they form the basis of an effective educational system.

Teachers must guide and correct students, when necessary, expand their thinking and provide them with new knowledge and information [28], and ensure that tasks are tailored to students' abilities [29] and interests through the use of individualised instruction [30].

Factors that support the learning process include flexibility in the curriculum and the use of non-traditional teaching methods. A learning environment can foster creativity through the flexible use of space and time during lessons, the use of the outdoor environment, opportunities for collaboration with external parties, and the presence of mutual respect between teachers and students [31]. The educational system must provide teachers with the opportunity to use such teaching methods, both in terms of the time to plan them and the space in which they work [32].

Teachers should make the rules clear [2, 33] and ensure that they are enforced. They must also help to promote cohesion [33] among students in the classroom. Active listening plays a crucial role in this process, encouraging both cooperation between group members [34] and communication between teacher and pupils. During the implementation of any pedagogical method, the teacher should allow students to freely express their thoughts about the subject matter without restrictions [28, 35], even if these thoughts differ from the majority opinion [33, 34]. This approach gives every student the opportunity to speak freely and share their ideas with the class. By expressing their views, the educational process becomes successful [36].

In addition, the teacher should encourage the exploration of each idea presented by the students, freeing them from the constraints that may be imposed by commonly accepted ideas and encouraging divergent thinking [29], which is the process of finding alternative solutions and is part of the thinking process, not the whole of it [37].

Effective, unrestricted communication [33] between students and between teachers and students is essential. The teacher, as a leading figure, supports students in achieving their desired goals and guides them in choosing a career that suits them [33]. By taking a genuine interest in his or her students, the teacher improves communication and cohesion in the classroom [38]. During the learning process, the teacher effectively addresses any cognitive or learning gaps of their students [2].

The teacher, when implementing any pedagogical method, should allow the students to express their thoughts on the subject freely and without any restrictions [28, 35]. This will allow each student to speak freely and share their ideas with the whole class, expressing their opinions will crown the educational process successfully [36]. At the same time, the teacher must encourage the students to explore each idea, but also free them from the limitations that may be imposed by ideas already accepted, by encouraging divergent thinking [29], that is, the mental process that allows the possibility of finding alternatives and that constitutes a part of the thought process rather than the whole of it [37]. They should also guide and correct where necessary, extend pupils' thinking and

provide them with new knowledge and information [28], ensuring that tasks are adapted to pupils' abilities [29] and interests through individualised teaching [30].

In general, by creating a supportive environment and developing positive interpersonal relationships, students' development is more complete and learning objectives are better achieved [39].

It is the teacher who should motivate his/her students to deal with a problem and also to achieve the desired educational goals. According to self-determination theory, motivation is intrinsic to students, linked to the desire to explore, discover and know better the world around them [40].

Motivation is the student's orientation towards a goal [41] and is directly linked to the acquisition of interest in the subject under negotiation [42]. At the same time, the teacher makes the students understand that they have the necessary abilities to achieve the desired educational goals [2]. This is the first condition that facilitates the development of motivation [40]. In this way, it pushes him to reach the end [41] and also to acquire a positive attitude [42] towards the subject being taught. During the student's work on a specific topic, the individual acquires autonomy, fulfilling the second condition that facilitates the development of motivation [40]. The third and last condition is the fact that the student feels that he/she is part of the group class [40]. The existence of a strong motivation leads to the activation of the student [41]. Its multiple role in the acquisition of motivation includes motivating students to participate in extracurricular activities that have a positive impact on students' learning abilities [43]. 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 [40]. The teacher, on his part, can greatly enhance motivation through feedback, rewards and direct communication with class members [40].

A teacher should also present his/her teaching material in a way that makes it more attractive to learners [2]. The teacher's main goal should be to teach students how to organise their thoughts and actions so that they can achieve their goals [15].

The teacher should also be able to use digital tools that are easily accessible, easy to use and do not require knowledge of programming languages [11]. Active learning contributes to the assimilation of new technologies and experimentation with new pedagogical methods [34]. It is ICT that can give students the impetus to develop their own independent research [44]. While the Industrial Revolution 4.0. defines the updating of educational systems to include technologies such as artificial intelligence, machine learning and algorithms [8], Learning Networks (LNs) and Virtual Learning Communities (VLCs) [44]. To achieve this inclusion, teachers should organise their classrooms accordingly and also adapt the processes of assessment, classroom management and pedagogical approach [8].

Requirements for STEM education

The implementation of STEM education in the classroom requires several skills from the teacher. A positive attitude towards this type of education can facilitate its application. This can be more easily achieved if teachers recognise that STEM education can help to improve students' academic performance [23].

Key characteristics of a STEM teacher include:

- In-depth knowledge of the subject they teach
- Use of innovative strategies
- Placing the student at the centre of the learning process
- Ability to address issues across disciplines
- Building cohesive teams [20]
- Research skills
- Lifelong learning
- Emotional intelligence
- Communication skills

- Use of ICT (Information and Communication Technology) [3]
- Linking classroom content to the real world
- Implementation of the curriculum [45]

In addition, a teacher delivering STEM education should not only have expertise in their specific field, but also have knowledge from other related fields [46]. When teaching, they need to be able to demonstrate how the subject matter relates not only to the specific discipline but also to other fields and real-life issues [3]. This approach helps to foster intrinsic motivation, which in STEM education can lead to the development of research, design and invention in various fields, moving away from traditional teaching methods based solely on the transmission and reproduction of knowledge [37].

At this point, it is worth mentioning another approach to STEM education where a problem or issue is taught through team teaching. In this method, each STEM teacher covers the part relevant to his or her area of expertise [18, 45]. In this way, a teacher is not required to have in-depth knowledge of all areas. However, this approach requires a high level of cooperation, coordination and detailed organisation, which can make STEM education more effective [45]. It also helps to overcome challenges such as the application of engineering, which research has shown to be the most difficult area for teachers to implement and which acts as a deterrent to STEM education [19, 47, 48]. By working together, teachers can each take responsibility for their area of expertise, with engineers, for example, taking on the engineering component and thus solving potential problems.

Teachers can also use problem-solving scenarios to encourage students to draw on the vast body of knowledge available in the modern scientific community [1]. The teacher must first design an authentic problem [49] and then use it, having established the learning objectives [1]. They must also create a learning environment that allows students to work appropriately to solve even vague problems while deepening their understanding of the subject [46]. In any case, effective teaching goes beyond the mere transmission of information, so the teacher must have strong communication and management skills [2]. In this environment, the teacher supports students and fosters positive attitudes in them [2, 33], which are further influenced by the interaction between class members [33]. Through STEM education, students' positive attitudes extend to the possibility of pursuing future careers in STEM fields [23].

Teachers guide students to solve problems without ever giving them a ready-made solution, thus enhancing their research skills [1]. It is also crucial to create a supportive and encouraging atmosphere for students, where diversity is embraced and stereotypes are eliminated. In this context, students with special needs have access to resources and strategies that can benefit them [2]. The class as a whole becomes an active participant rather than a passive listener [1], as students draw their own conclusions, which increases their motivation and perseverance to achieve the desired outcomes [23]. Access to quality education is a key element of the United Nations Sustainable Development Goal 4, and reducing inequalities is Goal 10.

21. st century Skills

The professional skills that a teacher needs to acquire are closely linked to the ultimate educational goal, i.e. the competence that students are expected to achieve at the end of the learning process. In order to achieve these objectives, teachers need not only to have a thorough knowledge of the subject they teach, but also to develop creativity, characterised by the use of new pedagogical methods [3]. At the same time, their teaching should be innovative, i.e. the application of new theories [3]. In the case of STEM education, the ultimate goal is for students to acquire 21st century skills.

Problem- solving

A key expectation of both students and employees is to be able to solve problems. To achieve this goal, pedagogical methods require a number of skills from the teacher. First, teachers need to give students the opportunity to collaborate with each other and with the teacher [41]. This requires

the use of collaborative teaching methods. In addition, teachers need to provide students with the right stimuli, not only to capture their interest, but also to encourage them to be innovative in their solutions [41]. The problems students are asked to solve should encourage creative and innovative solutions [41]. Combined with what has already been mentioned, the creation of a spirit of healthy competition and the teacher's encouragement of students to express and implement their ideas can have a positive impact [41]. Furthermore, the choice of appropriate teaching methods is again crucial, as they should encourage exploration, the processing of information and the verification (or rejection) of the initial hypothesis [41].

Research suggests that teachers have a significant influence on their students' problem-solving skills [16]

Creativity

One of the essential skills of the 21st century is the acquisition of creativity by students. It is believed that this skill is attainable by everyone, as long as they are in the right educational environment [14, 29, 32]. At this point, it is important to clarify that a creative individual is one who provides creative solutions to a given problem or issue. The first step in helping a person acquire the ability to be creative is to understand its definition and the vocabulary associated with it [37]. Therefore, teachers themselves need to place creativity at the centre of their teaching practice [37].

Two other ways to encourage creativity are to support the formulation of questions during the lesson and to provide opportunities for parallel activities initiated by the students [30]. Every question asked by a student, no matter how unexpected, should be seen by the teacher as an opportunity for the class to explore the answer, rather than simply providing the answer [35]. Teachers need to create conditions in the classroom that allow students to develop creative thinking and demonstrate confidence in their ability to succeed [30]. From a pedagogical perspective, the teacher's willingness to take risks by trying new exercises and approaches can also foster creativity [30]. In addition, moral rewards in the classroom can positively influence creativity by motivating students [43].

Another important skill for a teacher in STEM education is the ability to encourage students to explore ideas by crossing different learning domains, which enhances both learning and self-confidence [29]. It has also been recognised that the use of virtual reality and new technologies contributes to this goal [50]. Therefore, it is crucial for teachers to know how to use virtual reality tools and new technologies in general.

In order to promote students' creativity, teachers should avoid assessing imagination and focus less on deviant behaviour. They must also refrain from focusing solely on the end product and instead emphasise the learning process [30]. Another inhibiting factor in the educational process is anxiety, which often stems from students' difficulty in finding solutions to problems [42]. Anxiety is closely linked to the learning environment [42], which means that the teacher has a crucial role to play in reducing it through the atmosphere he or she creates in the classroom.

Critical Thinking

Critical thinking is another skill that teachers need to develop in their students. With the right methods, this skill can be developed in students [51]. It is important for teachers to have a thorough understanding of critical thinking theories and concepts, as well as to practice what they know in real classroom situations [51]. This equips teachers with the necessary pedagogical skills to pass on these skills to their students [17]. It also requires knowledge of appropriate pedagogical strategies [17]. As noted above, teachers must first master the desired skill and be critical thinkers themselves [17, 33, 37]. Therefore, they need to have well-developed and specialised knowledge and the ability to evaluate their students' thinking [37]. Teachers should develop students' ideas using collaborative teaching methods and be able to explain the origins of the rules and standards they are expected to teach. Teachers also need to conduct effective research and provide feedback to students to improve

their results [37]. By applying the process to different situations, teachers help students to become critical thinkers.

For teachers to develop critical thinking in their students through their pedagogical approach, they need to focus on lesson preparation to teach critical thinking skills. According to the literature review in [52], the lesson must be designed in such a way that the successful completion of the lesson requires the use of critical thinking. In this way, critical thinking becomes a learning objective [52]. Teachers should place more emphasis on analysis, interpretation, synthesis and evaluation of all available information [33, 53, 54]. Therefore, appropriate training is needed to guide students in distinguishing useful knowledge [11, 17]. This skill is closely linked to critical thinking and is essential in today's society where information is readily available online to all young people [12, 51].

In the classroom, this process can be encouraged by encouraging students to ask questions and demonstrating how to evaluate information [54], even when it is overwhelming. Teachers can support this by asking questions about similarities and differences between two topics, recording hypotheses and alternative solutions, using classification, and more [51]. Another strategy is to involve students in tasks that require them to analyse a wide range of materials of varying quality, helping them to learn to think critically about information [55]. This mindset can be transferred to their lives outside the classroom, as students acquire one of the key characteristics of an active citizen. Teachers are responsible for choosing the appropriate strategy to achieve the desired goal. Such strategies include writing critical essays, participating in discussions, writing research papers and case studies. Teachers should also take into account students' interests [51].

In addition, teachers can help students develop critical thinking by encouraging dialogue and exposing them to real-world problems [56]. Giving students opportunities to practice critical thinking in a variety of contexts is essential for success [51]. While critical thinking can improve with practice [37], it requires a sufficient number of tasks throughout the school year. Teachers can also improve students' skills by providing feedback [37] on how closely their results match the desired goals.

The teacher must also be able to plan activities to be carried out in the classroom that have clear objectives and are original [57]. In this way, the teacher strengthens his own critical faculty, so that he will be able to empower his students [11, 57]. The teacher must be able to choose the appropriate digital tools, the use of which will lead to the development of students' critical thinking [11]. Conceptual maps, identifying and coding key information, using analogies and interacting with key ideas are also considered helpful in this direction [57]. It is therefore necessary to provide in-depth teaching in the different areas and to acquire the skills that allow knowledge to be applied in practice. Finally, the acquisition of thinking skills is considered essential. The teacher, for his part, must promote high level thinking and increase mutual trust in the classroom [53].

Collaboration

To meet the demands of the 21st century, individuals need to develop collaborative skills, and teachers need to have these skills to pass on to their pupils. As with the other skills, the pupil must be at the centre of the process, with his or her needs at the forefront [58]. Pupils also need to be made aware of the importance of acquiring the social skills they will need in their adult and working lives [58]. Again, the structure of the lesson and the type of work assigned are key, as they should encourage students to work together and stimulate their curiosity to explore new topics [58].

Teachers need to identify pedagogical processes that not only place students in groups, but also use collaboration to produce tangible results [59]. To achieve the goal of fostering collaborative skills, teachers need to create an environment conducive to teamwork and use pedagogical strategies that encourage collaboration [58]. In this context, teachers should allow one pupil to help another in order to strengthen cooperation between them [58].

The e-Twinning network, which facilitates cooperation between teachers and pupils from different countries, has been shown to have a positive impact on the collaborative skills of both teachers and pupils. Teachers exchange ideas through discussions, while students work together on

predefined topics that involve sharing experiences [10]. STEM education, with its common goal of communication, fits well with e-Twinning activities. Students receiving STEM education can collaborate and interact with students from other countries, as they are better equipped to adapt. The production of content, such as videos, which requires technical skills, can also play an important role. In addition, engineering knowledge can be used to present topics related to both tangible and intangible cultural heritage, such as architecture and local traditions.

Collaboration within the group encourages mutual support for different creative ideas that may emerge [29]. Acquiring this skill is essential as it enables students to adapt to an ever-changing work environment [14].

Leadership Skills

A teacher's leadership skills are critical not only for the implementation of STEM education, but for any pedagogical method. Research [60] suggests that leaders acquire some of their leadership skills by observing successful leaders and learning from their behaviour. Teachers with leadership skills can serve as role models for students, who may in turn adopt these skills. A teacher with strong leadership skills becomes more effective [2], contributing to both the academic success of students and their high academic achievement [2].

Key components of leadership include maintaining order in the classroom, managing student behaviour [3], and improving the quality of education outside the classroom [2]. Whether during breaks or on field trips, teachers need to be in control. A positive classroom environment, both in terms of the subject being taught and the overall learning experience, helps to motivate students [34]. Through social awareness, a teacher leader prepares students for digital environments and fosters trust and cooperation among class members [34]. By communicating key information, they facilitate learning and encourage innovation [34].

To develop leadership in students, teachers should adopt a holistic approach that emphasises analysis and ethical development [60]. A multidisciplinary approach is appropriate [60]. Here, the interdisciplinary and holistic nature of STEM education plays a crucial role. In addition, ethical development includes consideration of factors such as environmental impact. As such, STEM education can help to develop leadership qualities in students.

The following are strategies that can be implemented to enable pupils to develop their own leadership skills. In addition to what has been mentioned in the previous paragraph, which relates to the leadership skills of the teacher, who is naturally leading by example. A key issue for a leader is to be able to communicate effectively with team members through both the spoken and written word [6, 61]. Speech is the main means by which a leader can communicate his or her vision [6] and the team's goals to team members. It is clear that the ability to develop written and spoken language is given through language learning and text comprehension courses. Therefore, at this point, the need to include in STEM education disciplines other than those mentioned in the acronym is reiterated. Through the group tasks set by the teacher to the pupils, the teacher should provide the opportunity to express ideas through written and spoken word and not just to present the result. At the same time, through group work they explore their creativity and gain flexibility [6] both in their thinking and in the way they solve a problem.

To cultivate leadership skills, teachers need to focus on both communication and problem-solving methods [61]. In addition, organising extracurricular activities such as sports competitions and encouraging participation in various school activities can have a positive impact on leadership development [62]. The presence of many different extracurricular activities in a school also has a positive effect [62]. Teachers encouraging their pupils to participate in these activities also has a positive effect [62]. In some cases, time-limited activities also teach students to make decisions under pressure [6].

Teachers with strong leadership skills have satisfied students who are productive and capable of achieving high goals [2]. The leadership skills acquired during schooling carry over into adult life,

allowing for lifelong development of these skills [6], and through lifelong learning, the opportunity to develop throughout one's life.

Lifelong Learning

Lifelong learning is essential in the 21st century and enables teachers to develop both personally and professionally [63]. This in turn has a positive impact on their pupils. This skill also enables teachers to resolve conflicts, work in teams and communicate effectively [63], all of which are critical in the classroom environment. Teachers need to manage their classroom effectively and resolve disputes between students to maintain control. In order to promote lifelong learning among students, educational programmes must enable teachers to introduce new teaching methods [25]. In this context, the teacher's role is to facilitate students' acquisition of knowledge rather than simply to impart it [25].

Supporting students' social skills and encouraging curiosity are central to teaching. The ultimate goal is for students to retain these qualities throughout their lives and to develop a passion for learning at every stage [25]. Teachers' use of technological tools also contributes to developing the capacity for lifelong learning [44]. Both the education system and individual teachers have a role to play in this by choosing appropriate assessment methods. Rather than categorising students according to their performance, teachers can use portfolios to collect and evaluate each student's work and make corrections through discussion. This method can encourage lifelong learning [15]. On the contrary, the use of folders in which students' work is collected, individually assessed and corrected through discussion can contribute to the acquisition of lifelong learning [15].

Self-esteem-building programmes and activities that link schools to the labour market also play a positive role in the development of lifelong learning [15]. To meet the challenges of lifelong learning, students need to learn how to learn [25]. This requires teachers to be familiar with and use student-centred methods. In addition, teachers should be lifelong learners themselves, keeping abreast of new teaching practices and applying them in their classrooms [15]. Teachers who are committed to lifelong learning adopt values such as respect, equality and solidarity, which they can pass on to their pupils [63].

Creating an environment that encourages curiosity, experimentation, problem solving and creative solutions also plays an important role [15].

Adaptability

Another critical skill is adaptability, which teachers need to instil in their students [64]. Teachers should set achievable goals tailored to students' abilities [64], recognise the different levels and abilities within the class, and use individualised instruction. Adaptability enables teachers to deal with unexpected situations in the classroom and to adapt their teaching to the needs of the students [64].

Discussion

Teachers are at the heart of the education system. Therefore, improving the skills acquired during their formal education and through lifelong learning ultimately benefits students by improving their academic performance [16]. Throughout their studies and careers, teachers refine their knowledge and skills, broaden their professional horizons and cultivate critical thinking [27]. It is widely accepted that early implementation of this type of education can have positive outcomes. It is therefore becoming increasingly important for teachers at all levels to acquire knowledge in this area [18].

This research aims to clarify the training goals for STEM educators so that they can be incorporated into teacher education programmes and other professional development initiatives. When teachers in STEM classrooms experience positive emotions, such as joy and happiness,

students are more likely to achieve their cognitive goals [23]. These positive emotions not only lead to desired cognitive outcomes, but also create a sense of satisfaction and positive attitudes towards teaching as a profession [27]. Such emotions can be fostered through well-structured curricula in teacher education programmes and professional development courses.

In addition, strong collaboration between school leaders and teachers can create an encouraging environment for the implementation of STEM education [23]. As mentioned above, STEM classrooms are guided by democratic principles and values such as sustainability, reinforced by scientific knowledge and the evolving nature of technology [18].

Equally important is the development of students' socio-emotional skills, which are linked to better academic performance from early childhood through to secondary education [39]. Teachers can contribute by supporting and communicating effectively with students [39].

The environment in which every teacher is called upon to teach is demanding and constantly changing, so good initial training and continuous feedback of knowledge is one way of achieving the objectives of modern education systems. A primary component is the teacher's desire to teach their subject and inspire their students. A STEM classroom, in order to lead its students to success - the acquisition of knowledge and skills - must first teach its students values such as respect for others, diversity and the environment.

Conclusions

Going back to the two main questions asked at the beginning of the survey, the answers are as follows:

1. STEM education is a new trend that requires highly qualified teachers. More specifically, the STEM teacher who has first mastered 21st century skills and is familiar with modern pedagogical methods can lead to the achievement of learning objectives and the acquisition by students of the skills necessary for our times. In general, a successful STEM classroom is governed by the basic principles of democracy, as there is a climate of respect, trust, free thinking and expression, cooperation and fair play in this classroom.
2. In the course of their studies or further training, teachers should acquire knowledge of the theoretical framework of 21st century skills. In particular, they should become familiar with the definitions of each skill and the pedagogical methods that can support them. A key feature of all these methods is that they place the learner at the centre of the educational process. The teacher is in the classroom with the primary purpose of ensuring that the rules are followed and that all students are treated equally. Lessons must be prepared in great detail, making use of new technologies and setting as learning objectives the acquisition not only of knowledge but also of skills. The design must also include authentic everyday problems. Pupils should benefit from the use of new pedagogical methods and exercises. In addition, students should be given an appropriate number of tasks that require knowledge from different areas in order to complete them. These tasks may take the form of research projects, case studies or case histories. The existence of motivation, but also the creation of a positive atmosphere and emotions, the cultivation of curiosity, can also be supportive factors. In the classroom, students are able to ask their questions freely without being subjected to any kind of commentary. Pupils also remain active listeners throughout the lesson, with the teacher supporting them every step of the way.

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