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## **Stem pedagogy to participate with Community learners**

### **Pedagogia e discipline STEM, un percorso attraverso comunità di apprendimento**

*di*

Valeria Caggiano

[valeria.caggiano@uniroma3.it](mailto:valeria.caggiano@uniroma3.it)

Amelia Broccoli

[amelia.broccoli@uniroma3.it](mailto:amelia.broccoli@uniroma3.it)

Università degli Studi Roma TRE

#### **Abstract:**

STEM (Science, Technology, Engineering, and Mathematics) education is becoming increasingly important in today's society, as technology continues to advance and shape our world. However, effective STEM pedagogy requires more than just teaching these subjects in isolation. It involves creating a learning environment that fosters interdisciplinary thinking, problem-solving skills, and collaboration among students and educators. One effective approach to achieving this is through the use of Communities of Practice (CoPs), which can provide students with a more holistic approach to learning. By breaking down the barriers between different STEM disciplines, creating a more collaborative learning environment, and providing students with an authentic learning experience, CoPs can help to prepare students for the real world and equip them with the skills and knowledge they need to succeed in the 21st century.

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**Keywords:** STEM pedagogy; Non cognitive skills; dialogue, community, training

**Abstract:**

L'educazione STEM (Science, Technology, Engineering, and Mathematics) sta diventando sempre più importante nella società odierna, poiché la tecnologia continua a progredire e a modellare il nostro mondo. Tuttavia, una pedagogia STEM efficace non si limita a insegnare queste materie in modo isolato. Un approccio efficace per raggiungere questo obiettivo è l'uso di comunità di pratica (CoP), che possono fornire agli studenti un approccio più olistico all'apprendimento. Abbattendo le barriere tra le diverse discipline STEM, creando un ambiente di apprendimento più collaborativo e fornendo agli studenti un'esperienza di apprendimento autentica, le CoP possono contribuire a preparare gli studenti al mondo reale e a dotarli delle competenze e delle conoscenze necessarie per avere successo nel XXI secolo.

**Parole chiave:** pedagogia STEM, competenze non cognitive, dialogo, comunità, formazione

### 1. Introduction<sup>1</sup>

STEM (Science, Technology, Engineering, and Mathematics) education has become increasingly important in today's society as technology continues to advance and shape our world. Pedagogy, the method and practice of teaching, is also evolving to meet the demands of this rapidly changing landscape. The integration of STEM disciplines in education has the potential to provide students with the skills and knowledge needed to succeed in the 21st century. However, effective STEM pedagogy requires more than just teaching these subjects in isolation. It involves creating a learning environment that fosters interdisciplinary thinking, problem-solving skills, and collaboration among students and educators. This can be achieved through a variety of approaches, including project-based learning, inquiry-based learning, and the use of technology to facilitate active and engaging learning experiences. Additionally, the incorporation of real-world applications and hands-on experiences can make STEM education more relevant and meaningful to students. As STEM education continues to evolve, it is essential that pedagogy also evolves to ensure that students are prepared for the challenges and opportunities of the future.

Gender equality in first and second level education has been achieved: the female population in Europe is even more inclined to engage in university studies. This problem needs to be addressed as it is an important piece in the 'gender gap', which has major implications for the future of women and society (Corlu, Capraro & Capraro, 2014). The technology driven innovation that the world is currently going through demands better and necessarily specialised persons (Hallström & Schönborn, 2019). The technical and scientific knowledge demanded by Industry 4.0 marks STEM studies, such as science, technology, engineering and mathematics courses. However, women are unfortunately being partially left out of this epoch-making transformation. The statistics speak for themselves: globally, less than 4 out of 10 graduates in STEM subjects are women.

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<sup>1</sup> The manuscript is the result of a collective work of the authors, the specific contribution of which is to be referred to as follows: introduction 1, paragraphs 2 and conclusions are attributed to Valeria Caggiano; paragraphs 3 is attributed to Amelia Broccoli.

Therefore, there is also a real 'gender gap' in both education and employment in this area. To date, the 'gender wage gap' - the pay gap between women and men - stands at around 16% in Europe. The risk is that this gap will not be closed without promoting gender equality in STEM fields. Gender inequality is also visible in research and universities: women researchers worldwide account for only 30%. In Europe, as can be seen in the graph below, women scientists are consistently less than men. Consider a press release from the European Commission on Education and the Workforce (2020), which states that although the number of well paid STEM jobs is growing fast, the supply of workers with the necessary skills to fill these sought-after positions decreased during the first half of the decade<sup>2</sup>. There are classic signs of supply adequacy or even oversupply in some STEM fields. For example, median hourly earnings in two IT occupations (systems programmers, computer scientists, and researchers) by about 1.9 per cent on average between 2010 and 2020 (BLS, 2020 Occupational Employment Statistics). Furthermore, Noonan (2017) reports that nearly two-thirds of STEM graduates work outside the STEM SECTOR. To some extent, wage growth could be held back by workers changing jobs and moving to other high-skilled occupations that slow down the economy. The issue of appropriate job vacancies for appropriate workers is further complicated by changes in the drivers of the labour force, which are the externalisation of STEM work and the rise of automation (Watson et al., 2020).

Concerns regarding a possible lack of qualified technical personnel has involved the highest levels of government. Kelly, and Knowles, (2016) show that various policy reports at national level by professional organisations are promoting the view that the educational sector needs to be redesigned to ensure an appropriate STEM human resources workforce. Stakeholders are in agreement on a few facts: the labour market for STEM skills is rapidly changing, and STEM education is expected to be responsive to new trends. Consequently, it has been suggested to rename STEM to STEAM or actually to STREAM. By The way, the performance of these different perspectives can be various and modified (e.g. A can be decoded as Art or as Everything; R could be decoded as Reading, as Writing, RELIGION<sup>3</sup>).

In this article, we are dealing with the educational contribution of exemple, the models to be imitated. The contribution comes from a study for the presentation of a laboratory activity designed for a Master designed in collaboration between Roma Tre and Rome Business School, as Humanistic Module. The proposed topic focuses on the analysis of soft skills, transversal skills, which have a pivotal role in contemporary educational literature and which indicate directions the third level education must take. Among the soft skills considered strategic for the purpose of a considerable role is given to leadership, not only intended as a recognizable and transformative power, but also as a competence that comes from exercise and practice. The aim of this activity is reflect on Stem education behind the reflexion on community and classics refernces.

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<sup>2</sup> According to a report by the National Science Foundation, the number of STEM jobs is projected to grow by 8.8% between 2018 and 2028, compared to 5.0% for non-STEM jobs. (Source: National Science Foundation, "Science and Engineering Indicators 2020," February 2020).

<sup>3</sup> Research has shown that early exposure to STEM education can have a positive impact on student outcomes. A study by the National Science Foundation found that students who participated in STEM activities before high school were more likely to pursue STEM degrees in college. (Source: National Science Foundation, "Women, Minorities, and Persons with Disabilities in Science and Engineering," January 2019).

## 2. Studia Humanitatis and not cognitive skills for SteAm Education

When, therefore, one speaks of humanitas -in the form of *studia humanitatis*, "humanism," "humanistic studies," humanities- with regard to the study of classical culture, what one assumes, or should assume, is that this study is intended to increase the level of "humanity" of those who practice it: by stimulating spiritual faculties that are both culture and equity, knowledge and generosity, knowledge and responsibility, *paidéia* and *philanthropía*. That indeed precisely *philanthropía* appears to be an attitude of crucial importance in Western societies today: when we speak of "humanitarian" dispositions or practices" - and we use this expression behind the impulse of the fran -.that we consider truly "humanistic":that relating to the fact that, as Michel de Montaigne said, there is no one and only one way of being in the world, but there are "thousand contrary ways of life," different from the one practiced by us"<sup>4</sup>.The interplay of identity and otherness-the recourse to antenatias a pledge of cultural continuity but, at the same time, a paradigm of otherness-in short, induces tolerance and mutual understanding between cultures: an attitude that is more desirable today than ever before. Experiencing the otherness of the Greeks and Romans also induces us to think that different ways of life, even when they come to us from societies distant in time or space, are not necessarily inferior to ours, outdated or simply barbaric cultural models; on the contrary, we can realize that in these different cultural configurations there are extremely interesting elements of civilization, on which it is worth reflecting especially to better understand "us" as well as "them." And this constitutes, along with tolerance, an extremely important intellectual acquisition. [If carried out from such a perspective, the study of classical civilization can turn into a training ground as much for identity and continuity-through the discovery of the multiple cultural ties that unite "us" with "them"-as for otherness and discontinuity: "us "and "them" as cultures in comparison, diffe- rent ways of understanding life and society.In this area, the humanists recovered the ideals of Greek *paidéia*, in particular the Spartan *paidéia* with regard to physical exercise aimed at military virtue, and the Athenian *paidéia* with regard to the coexistence of literary culture, music and gymnastics within the educational curriculum, in view of a harmonious and complete individual development. The centrality of man is accompanied, in education, by the centrality of the text. The real revolution practised by the humanists is that of giving a new and authentic voice to the ancients, freeing them from the ahistorical medieval superstructures (a process that had already begun with Petrarch): "The restoration of the ancient as such, that is, the recovery of the sense of human diversity, of the actual historical dimensions, was the 'discovery' of the ancient made by the humanists, their discovery of man as a historically concrete and determinable individuality. On a specifically educational and didactic level, it led schools to privilege the direct and extensive reading of poets, historians, orators, over the *notorious auctores octo*<sup>5</sup> or the compilations of the Middle Ages.

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4 M. De Montaigne, Saggi, I, xxxv, *Catone il giovane* (citiamo dalla traduzione a cura di F. Garavini, Mondadori, Milano 1970, p. 300).

5 The auctores octo were "the Disticha Catonis, the Theodolus, the Facetus, the Floretus, the versified Aesop, the Tobias of Matthew of Vandôme, the Parables of Alain of Lille, the De contemptu mundi or the Chartula, many times copied and then printed, for use in schools", E. Garin, *L'educazione umanistica in Italia*. Bari: Laterza, 1949.

In the hybridisation 'etymon' itself, we may actually read a more problematic connotation, according to the Greek root that finds in *hybris*, the sin of hubris towards the destiny established by gods. The contemporary context of the gradually more open approach to the contamination (cross-fertilisation) of knowledge appears to be showing a clear phase of change, in dialectic with the late modernist tradition that has come down to the present day, which bet on the hyper-specialisation and segmentation of knowledge and skills. Indeed, our contemporary society still promotes a specialised approach to learning, as opposed to the trend towards syncretic knowledge (Casalini, 2022). The relation between the progress of technology and human life, which is becoming increasingly intertwined, shows us radical transformation scenarios of the future fates of individuals and their communities.

The designed reforms at Eu level but following international standards of tertiary education, provide for integration of education in all disciplines and where trans-disciplinary approach in different formats, such as organising interdisciplinary curriculum days in which students learn about certain topics during the entire course of each day and investigate it from different perspective (physics, chemistry, history, art, etc.). In addition, it incorporates aspects of international educational programmes such as Science education (European Commission) and Education 2030. In spite of the circumstance that STEM-education is not formally declared as necessary being implemented, the new curricula do include its elements such as research project and it is planned to be implemented in the interdisciplinary subject 'Science', which, in addition to being transdisciplinary, involves the use of the research-based methods. The generation of educational resources for teaching STEM subjects is no longer dependent on the activities of traditional educational editors. This means that different editors can provide the STEM-based content literacy investigation, an important role being played by cloud-based educational environments. Than traditional approaches to education ensure new opportunities to provide experimentation or displays<sup>6</sup>. Moreover, cloud-based learning experiences are marked with the possibility to bypass the limits of the conventional classroom, can supply an interactive method of active learning and can deliver human-centred education. However, one of their benefits is the possibility to detect the trends in educators' learning needs by using the results of SEO analysis. Nevertheless, no statistical open-source reports on the current status and trends in this field are provided. Moreover, other frameworks do provide an analysis of the present state of trends in STEM education. Much evidence suggests that STEM-skilled workers play an expanding role in guiding economic growth (Peri, Shih & Sparber, 2015). Liberal education has historically been divided into the trivium of 'grammar, rhetoric and logic' and the quadrivium of mathematical or 'learnable' arts, dimensionless arithmetic and geometry, astronomy and music. With a discussion-based approach to the great books of the Western worlds serving as the strong framework of its

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<sup>6</sup> Effective STEM pedagogy involves not only teaching the content of STEM subjects, but also promoting the development of 21st century skills such as creativity, critical thinking, and collaboration. A report by the National Academies of Sciences, Engineering, and Medicine recommends that STEM education should be integrated with other subjects, such as the humanities and social sciences, to foster a more well-rounded education. (Source: National Academies of Sciences, Engineering, and Medicine, "The Integration of the Humanities and Arts with Sciences, Engineering, and Medicine in Higher Education," 2018).

curriculum. According to the 'moral' and 'civil' point of view proposed by Eugenio Garin<sup>7</sup>. Garin in the 15th century treatises on education. Man is considered first and foremost as a citizen, in a social view according to which individual education is never an end in itself but must always aim at the common good, at civil life, and liberal education is the ideal means to form the complete man, capable of operating well in favour of the community. 'Totality' is expressed both in the disciplines that the Humanists propose as subjects of study (grammar, rhetoric, dialectic, arithmetic, geometry, astronomy, music, according to the traditional distinction between trivium and quadrivium; but also philosophy, history, natural sciences, drawing, medicine, law...), and in the importance attributed to the knowledge of languages (Latin, Greek and, in more mature Humanism, also Hebrew), and in the desire to exercise both the mind and the body.

Economists tend to use the term 'non-cognitive skills', psychologists use mainly 'social-emotional skills', while studies in business and management or education research emphasise 'soft skills' (Sanchez Puerta et al., 2016). Additionally, the wide range of skills, traits, beliefs and behaviour collected under the 'non-cognitive' indicator contains a highly varied range of attributes, including motivation, self-confidence, persistence, social and communication skills. Each of these has a distinct and very long history of methodological and other theoretical perspectives, which makes any measurements very difficult. For this reasons, self-report and teacher-report surveys are more frequently used in the measuring of non-cognitive skills, as they are cheap, fast and reliable (Connelly & Ones, 2010). Ultimately, the fundamental restriction lies in the distinction between the cognitive and non-cognitive learning. This term 'non-cognitive' highlights an inappropriate differentiation between the cognitive and non-cognitive factors.

### **3. Dialogue, Community, and the Classics**

In this section, the centrality of dialogue to the creation of a community of learners will be considered.

As is obvious, education should not consist solely in imparting notions and information to students, but rather in cultivating critical thinking skills and fostering in them a sense of curiosity for research. Dialogue is an effective tool to achieve this. By engaging in meaningful conversations with others, students are encouraged to explore their own beliefs and values and challenge those of others. This is very likely to create an environment where pupils are not only exposed to new ideas, but are also encouraged to develop their own unique perspective on the world.

An effective way of fostering dialogue skills could be to start with the critical reading of classical texts and reflect deeply on their meanings and implications. The group discussion format of dialogue allows students to develop a deeper understanding of the material, as it enables them to evaluate the perspectives and interpretations of others. To be effective, the dialogue must be 'facilitated' in a way that encourages the participation of all group members. This means that the facilitator must create a safe and inclusive environment in which all ideas are welcomed and respected. The best example to

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7 E. Garin, (1965). Education and the Renaissance. In G. Salton (Ed.), History and Philosophy of Education: Voices of Educational Pioneers (pp. 15-27). New York: Teachers College Press. Garin's 15th century treatises on education propose a "moral" and "civil" point of view that emphasizes the importance of liberal education.

look at in this regard seems to be the Socratic dialectical methodology described by Plato in many of his finest dialogues. Let us briefly see what this is all about.

The first thing to observe is that with Socrates, the dialogical word is given an ethical-existential turn, since dialoguing and communicative action become 'openness to the other' and the 'search for a shared meaning'. But dialogue is not only the tool used by Socrates to probe the soul of others with patient excavation work. It is the means and end of his education. It is the practice of life and a way of understanding philosophy. One can perhaps speak of an educational 'technique', but it is clear that it is not a technique in the manner of the Sophists. Indeed, Socrates understands *paideia* as an education of a moral kind, which does not aim to teach instrumental skills or competences, but to make people reflect on right and virtuous behaviour. Through incessant questioning, the philosopher wants to make his interlocutor aware of the values that dwell within him, leaving the disciple free to find himself. It is not an authoritarian education, therefore, but a natural self-education favoured by his maieutic capacity.

Dialogical methodology also has a strong community orientation and this too can serve as an example to foster a sense of community among students and create an environment in which all members feel comfortable sharing their thoughts and opinions.

The early Platonic dialogues are proof of this. The Athenian philosopher exercised his role as a dialogical man and worked throughout his life to argue the case for communal research. As D. Di Cesare, "if Socrates takes refuge in discourses - ultimately - it is because he does not arrogantly presume to be able to see things only with his own eyes and is therefore willing to listen to the word of others. It chooses the commonality of logos, dialogue. More than an escape, it is the entry of philosophy into the world of the polis, the city community"<sup>8</sup>.

The idea of the individual-community nexus, therefore, emerges explicitly from the teaching of Socrates, who seems here to consider the positive effects of the virtue of individuals on the morality of the entire city. Virtuous individuals will make the whole state virtuous, in short. And attention to the virtue of individuals cannot be separated from that of the rest of the city.

The instrument of dialogue therefore has an educational, ethical and political value at the same time. In Socrates, there is no fracture between the gnoseological content and the ethical aspects of education because philosophical research is total and complete *paideia* for the care of the soul: "It is precisely this," he says in the *Apology of Socrates*, "that is the greatest good for man, to reason every day about virtue and the other subjects about which you have heard me argue and make research on myself and others, and that a life that does not make such research is not worthy of being lived"<sup>9</sup>.

This means that dialogue, understood as the search for values, itself constitutes the greatest value. And if dialoguing is equivalent to seeking virtue, it follows that dialogical research and moral research coincide. Dialoguing qualifies as an "ethical relationship" between men, and it only acquires value if it is configured according to the stages of the virtuous circle between the relationship, to which the search for the meaning of virtue is subtended, and the search for virtue, which in turn is marked out according to dialogical-relational modes of communication.

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8 D. Di Cesare, *Sulla vocazione politica della filosofia*, Bollati Boringhieri, Torino, 2018, p. 51.

9 Platone, *Apologia di Socrate*, 38 a.

Working 'with' dialogue and 'on' dialogue, in other words, becomes an open and circular research, in which knowledge is not presupposed to investigation, but emerges from the latter. Only at the end of the process can the discovery of truth emerge, which will be the shared fruit of the communicative relationship between the dialoguers. Ultimately, process prevails over the transmission of content, open enquiry over the mechanical passing on of information and knowledge.

It follows that education and communication will not be able to consist in the teaching of an abstract theory, but will translate into a concrete proposal for the acquisition of a lifestyle that knows how to combine theory and practice throughout existence. Indeed, the Socratic logos is never pure theoretical speculation. It is word that must be translated into lived life, it is 'logos' that goes hand in hand with 'bios', it is the search for a dialogical truth that can guide human behaviour in an ethical sense.

It seems difficult not to see in this Socratic behaviour a clear encouragement to use critical thinking. Indeed, he declares that he has "never been anyone's teacher"<sup>10</sup>. The Athenian philosopher teaches nothing, in other words, because there is nothing to teach, and because he refuses to restrict the issues he deals with on a daily basis, the ethical issues, within the usual communicative limits. Socrates teaches nothing, not because he does not know what to teach, but because he believes that the true object of teaching cannot be conveyed by words. It is as if he perceives the inadequacy of verbal language to express things so profound and delicate that they cannot be said.

How, indeed, can one communicate and teach virtue? How can one teach the good and the good? How can the universe of moral experience be brought into the confined space of the word? There is, in short, a kind of irreducibility to the word of inner experience, which does not allow itself to be grasped completely, which attempts to escape the geometric perimeter of the logos. This is why it has rightly been argued that Socratic education does not rest on any specific content, but resolves itself in a continuous tension towards knowledge that is never given.

#### 4. Conclusions

In this article, we are dealing the contents to supply a Module of Humanism Management designed for a Master between university and companies. The Module is addressed to SteAm education, the aims are improve not cognitive skills behind the Gallery Proposals that include Classics Studies and behind Communities of Practice (CoPs).

We agree respect to the needs to dialogue with Classics and in the Classics vision. Whereas basic skills are mainly acquired through schooling, the rest are developed and reinforced by dimensions and parallel environments, by social and psycho-social interactions that strengthen, and in some cases invalidate, the competences involved in the acquisition of non-cognitive skills. An inclusive education and training system that strikes a balanced relationship between cognitive and non-cognitive skills curriculum is key to a society able to cope successfully with social economic inequalities, poverty, discrimination and social exclusion (OECD, 2022). STEM education is not just about teaching students the basic principles of these disciplines. It is about preparing them for the real world, where these subjects are often interrelated and used in conjunction with each other. One way

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<sup>10</sup> *Ivi*, 33 a.

to achieve this is through the use of Communities of Practice (CoPs), which can help to bridge the gap between different STEM disciplines and provide students with a more holistic approach to learning. CoPs are groups of people who share a common interest or goal and interact regularly to learn from each other. In the context of STEM education, CoPs can be formed among students, teachers, and professionals in the field. These groups can help to provide students with a deeper understanding of the subject matter by creating an environment in which they can learn from each other and work together on projects.

One of the key benefits of CoPs in STEM education is that they can help to break down the barriers between different STEM disciplines. For example, a CoP consisting of students from different STEM fields can work on a project that requires knowledge and skills from each of their respective fields. This can help to create a more interdisciplinary approach to learning and help students to see the connections between different STEM subjects. CoPs can also help to create a more collaborative learning environment. In traditional classroom settings, students are often taught in isolation and are evaluated based on their individual performance. This can lead to a competitive and individualistic mindset that is not conducive to collaboration. CoPs, on the other hand, are based on the idea of shared learning and collaboration. Students work together to achieve a common goal and are evaluated based on their group's performance. This can help to create a more supportive and collaborative learning environment that encourages students to work together and learn from each other.

Another benefit of CoPs in STEM education is that they can help to create a more authentic learning experience. In traditional classroom settings, students are often taught in a way that is disconnected from the real world. CoPs, on the other hand, can help to create a more authentic learning experience by providing students with opportunities to work on real-world problems and projects. This can help to make learning more engaging and meaningful for students, as they can see the direct impact of their work on the world around them.

In order for CoPs to be effective in STEM education, however, they must be well-designed and well-implemented. This requires careful planning and coordination among teachers, students, and professionals in the field. Teachers must be willing to collaborate and work together to create a supportive learning environment. Students must be willing to work together and share their knowledge and skills with each other. And professionals in the field must be willing to serve as mentors and provide guidance and support to students as they work on their projects. In conclusion, CoPs are an effective way to promote STEM education and provide students with a more holistic approach to learning. By breaking down the barriers between different STEM disciplines, creating a more collaborative learning environment, and providing students with an authentic learning experience, CoPs can help to prepare students for the real world and equip them with the skills and knowledge they need to succeed in the 21st century.

This paper concludes that a discussion-based business pedagogy anchored in the liberal arts and sciences leads to eight main learning outcomes (1) how to reconcile opposing arguments; (2) how to think on one's feet; (3) how to enable students to learn better by motivating them to prepare better for life; and how to integrate new ideas from different views and disciplines.

In this sense, the educating community represents a model of education that integrates the individual and collective sphere, in which each member is both an educator and a learner, in a process of constant learning and growth.

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