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Work package n°2 - Framing: M-STEM Pedagogical Strategy - Chapters

Chapter 5: The Importance of STEM Education in the Digital Age

Inspectoratul Scolar Judetean Teleorman

ROMANIA

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Introduction

Modern societies, especially those in the European Union, have begun to focus on sustainability, highlighting the challenge of climate change. The energy transition requires citizens to have green and entrepreneurial skills, which are developed in combination with basic skills and, of course, soft skills. In this scenario, digital skills are also part of the skills that European citizens should have in their daily lives. This combination of skills is supported by European policies, both through sectoral and cross-cutting policies, such as the European Green Pact, the EU Skills Agenda and A compass for the digital dimension.

At the *ALL DIGITAL* Summit, which took place on 14 October 2021, Anusca Ferrari, EU Policy Officer, in her speech at the opening of the event, highlighted the objectives and initiatives of the European Union: "We have established that STEM is a priority for higher education cooperation projects in the Erasmus+ 2021 work programme. [...] Only 1 in 5 young people in Europe graduate from STEM tertiary education, and in European Union we have less than 2 million STEM graduates annually. Even if we try to promote an inclusive approach to STEM education, we know that, in fact, women are strongly under-represented in the sector: 1 in 3 STEM graduates is female. The situation is even worse when we look at ICT studies, where only 1 in 5 ICT graduates is a woman."

Consequently, in the rapidly evolving landscape of the 21st century, the integration of Science, Technology, Engineering, and Mathematics (STEM) education has become imperative for preparing students to thrive in the digital world. As technological advancements continue to shape our society, STEM education serves as a catalyst for innovation and progress. This chapter explores the changes that have appeared in education as a result of the 4th Industrial Revolution, the significance of STEM education in the digital age, its impact on student learning and the skills they will acquire, as well as the evolving role of educators in fostering a generation of digitally literate individuals.

- **Education requirements in the 21st century**

In the last three centuries, mankind has witnessed four Industrial Revolutions which have caused gigantic leaps in industrial development. The impact they have had on human civilization and the way we live our lives is massive. The first industrial revolution took place in the 18th century, when the steam engine was introduced, completely transforming the

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transportation and manufacturing sectors. The 19th century was clearly marked by the introduction of electricity and mass production, which is known as the second industrial revolution. The third one, attributed to the 20th century, brought with it semiconductors, computing and the use of internet, thus connecting people all over the world, but, at the same time, resulting in the globalization of communication and trade.

The current era, referred to as the 4th industrial revolution, is characterised by unprecedented invention and rapidly emerging technological breakthroughs, which has led to a such a fast pace of digital transformations and fusion of technologies that the boundaries between the physical, digital and biological spheres are no longer clear, but, on the contrary, they transcend and blur.

We have been the witnesses of the 'unthinkable' becoming a reality, when artificial intelligence, 3D printing, autonomous vehicles, nanotechnology or sophisticated robots have become part of our daily lives. All these innovations, collectively, have done nothing else but emphasize the importance of STEM and the role of STEM competences in contributing to economic growth, productivity and meeting future demand.

Given the above-mentioned transformations, education could not have remained "untouched" or "resistant" to change. Since the first industrial revolution, schools have taken on the mission to prepare students for the workplace, equipping students with basic skills, by providing a certain body of information, considered not only important but also viewed as norm by the majority.

Nowadays, however, the expectations are shifting – the students educated in today's schools are expected to function, in a not very remote future, as adults belonging to a rapidly changing world, work under conditions characterised by uncertainty; moreover, these future adults will have to deal with a continuously increasing amount of information, become familiar, or even master, new technologies; these new mediums will facilitate their work, collaboration and communication.

Knowledge and knowledge-oriented practices are assuming greater importance than ever before. More than that, tomorrow's adults will compete over jobs with millions of people from all over the world, as a consequence of digitalization and globalization. Therefore, it comes as no surprise that educators, parents, business leaders and policy-makers express their concerns that education institutions, too often, fail to prepare students for the demands of the 21st century.

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This is the reason why many states are attempting to change their schools and adapt them to the 21st century demands, by introducing or, in some cases, even imposing various reforms in education. The problem is that these changes and reform processes engage teachers' knowledge and commitment; actually, it is paramount that teachers exercise their own professional judgement in the change process, which has proved to be not at all easy.

- **The new skills in an era of change**

Today's society expects schools to foster knowledge creation and life-long learning skills. Graduates of 21st century schools must be proficient in the basic academic skills areas of reading, writing and elementary mathematics, but, at the same time, they must be prepared to learn new things, collaborate in identifying solutions to various problems and produce innovation in areas that currently may not even exist.

Scholars have come up with many terms, trying to describe and articulate this range of skills (such as the 21st century skills, life-long learning skills or 21st century competences). They have also made attempts to define the competences, abilities and dispositions people need in order to be successful in tomorrow's world.

One such classification refers to **four main domains**: (meta)cognitive, inter-personal, intra-personal and technological. Skills in the cognitive domain span the learner's ability to construct meaningful and in-depth knowledge, as well as to apply it creatively in new situations and contexts. **Metacognitive** awareness and self-directed learning were ranked as important cognitive attributes. The **inter-personal** domain deals with a person's ability to engage with others, such as through teamwork, leadership and cooperation, whereas the

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intra-personal domain concerns one's response to problems and challenges, such as intellectual openness, self-regulation and managing emotions. Finally, the **technological** domain relates to one being literate with respect to information and communication technology (ICTs).

Technology does play a crucial role in teaching today. Even in schools with low or limited use of it, metaphorically, technology has entered "through the back door". No matter where one teaches, when giving homework assignments, educators need to take into account that students may use the internet (even searching for ready-made essays or solutions to problems), which will definitely diminish the intellectual efforts required.

That is why, the voices from media and academics are split between those with pessimistic versus optimistic opinions about the effects of ICTs on young people. Those in favour of introducing technology in classrooms see it as an opportunity for "self-expression, sociability, community engagement, creativity and new literacies", whereas pessimists consider "social networking as time-wasting and use of other ICTs in schooling as taking shortcuts, cheating, that may have a negative impact on the development of study skills". Whether we belong to the category of optimists or to those who fear the dangers it might bring along, we must all acknowledge the transformational role of technology in both students' and teachers' lives.

- **The importance of STEM skills in ensuring a sustainable future**

The United Nations' 2030 Agenda for Sustainable Development, titled "Transforming our World", has established 17 Sustainable Development Goals, whose fulfilment will have as result a diminishing of poverty and food shortage; they will also help to deal with issues such as climate change, the protection of the planet and will ensure that all individuals enjoy peace, prosperity and a quality of life for all.

Education, and particularly STEM education, plays a crucial role in achieving these goals. Here are the particular areas where STEM education is expected to elaborate and provide innovative solutions that will solve global issues: *Zero Hunger* (which was established as Sustainable Development Goal no.2); *Good Health and Well-Being* (Sustainable Development Goal no.3); *Clean Water and Sanitation* (Sustainable Development Goal no. 6); *Affordable and Clean Energy* (Sustainable Development Goal no. 7); *Decent Work and Economic Growth* (Sustainable Development Goal no. 8); *Industry, Innovation and Infrastructure* (Sustainable Development Goal no. 9); *Sustainable Cities and Communities* (Sustainable Development Goal no. 11) *Responsible Consumption and Production*

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(Sustainable Development Goal no. 12); *Climate Action* (Sustainable Development Goals no. 13).

The question therefore arises: how can STEM education bring its crucial contribution to achieving all these goals? In order to provide the best answer and examples, it is necessary to mention the different conceptions of what STEM means in practice; the perspective from which it is viewed within the education system appears to be the most important defining factor.

There are many people who think of STEM as four separate subjects (Science, Technology, Engineering and Mathematics). Others consider STEM to be an integration of two, three or all four disciplines. It is true that each of these disciples has its own history, philosophy and principles, as well as its own knowledge, skills and functions; nonetheless, in the last decades, researchers considered that the four disciplines should be brought together, as STEM; they support their claim with the main argument that science and mathematics are generally considered to form the basis of applied science, which includes technology and engineering.

The entity now known as STEM, first proposed in the 1990s by the US National Science Foundation, addressed a rising concern that many students would not be able to keep up with the changes brought about by the digital revolution, and might even be left behind, in the globally competitive marketplace. An increasing demand for STEM related skills and competencies was therefore felt deeply.

How can we define STEM competence? Can we refer to it as a mere set of fixed skills or is it rather a developmental capacity? According to specialists, STEM competence defines an individual's ability to apply STEM knowledge, skills and attitude appropriately in his or her everyday life, workplace or educational context. It includes both the 'know-what' (the knowledge, attitudes and values associated with the four disciplines) and the 'know-how' (which refers to the skills that are needed to apply that knowledge, taking account ethical attitudes and values in order to act appropriately and effectively in a given context).

After we have pointed out the complex contents of STEM competence (as comprising knowledge, skills, attitudes and values), further on, we would like to present, in more detail, the main skills which are required in carrying out STEM-related tasks. They include cognitive, manipulative, technological and collaboration and communication skills.

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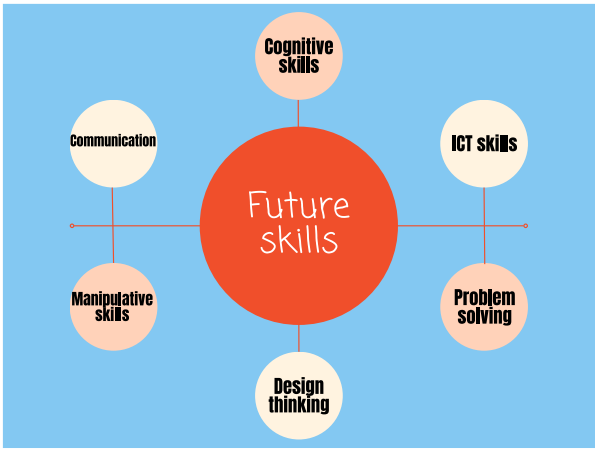

Cognitive skills - the range of cognitive skills needed include: information management and processing, (identifying, collecting, processing and using relevant data to make decisions) critical, creative and analytical thinking, problem solving skills, scientific investigation, creativity and computational thinking. In today's society, enormous amounts of information are gathered and used in all domains of life. Information processing skills are thus required to find, collate, organise and select valid information for specific tasks; this is needed in order to generate, understand, interpret and analyse empirical data, but at the same time, to test its authenticity, validity and reliability.

Another important skill developed through STEM education is that of **problem solving**: the process is a complex one, which consists of identifying and breaking down complicated problems into parts or components, analysing data, developing solutions, evaluating options and implementing solutions. This skill turns out to be useful in **scientific investigation** too, which scientists use to explore and find answers to existing phenomena in the world around them.

The effective use of **Information and Communications Technology** (ICT) skills and connectivity are important to the advancement of the STEM fields. Basic ICT skills include the technical ability to use a computer, tablet or mobile phone, send emails, browse the internet, make a video call and use computer software to search for information and create presentations. Coding is another essential skill which involves programming sets of instructions or algorithms to enable computers or ICT gadgets to perform certain tasks

Design thinking has become a necessity in this age of great innovation, invention and creativity and it involves a structured framework of creative strategies and processes to develop products and solutions, not restricted to rigid techniques or rules. Design thinking is based on information gathering, creative brainstorming, trial and error, review, redesign,

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testing and implementation that can be effectively applied to STEM learning and STEM careers.

Manipulative skills refer to the correct and safe use and handling of scientific and/or technical equipment, apparatus, specimens and substances which may be specific to a particular career or vocation, among which we can mention electricians, cardiovascular technologists, aircraft mechanics or mechatronics engineers.

When referring to **vocational or technological** skills, we mainly associate them to the training some countries provide at secondary schools which assist students to make more informed decisions about their future careers. However, because vocational skill-sets constantly and rapidly change, schools often find it a challenge to keep up to date with innovations.

Effectively collaborative and communication skills do not always occur naturally and need to be explicitly developed; effective teamwork is required since the majority of tasks are complex and interrelated and cannot be achieved by a single person's effort. There are multiple benefits of effective collaboration, among which the equal chance every team member has to participate and communicate ideas, as well as assuming and sharing responsibility.

- **Challenges of STEM education in the digital era**

For generating and implementing a pedagogical transformative change, teachers are essential. Well-educated and highly-motivated teachers are at the core of successful educational systems. Barber and Mourshed, two highly respected researchers, pointed out that the quality of an education system cannot exceed the quality of its teachers; they also stressed the fact that the only way to improve outcomes is to improve instruction and achieving universally high outcomes in only possible by putting in place mechanisms to ensure that schools deliver high quality instruction to every child. (Barber, M., & Mourshed, M. (2007). How the World's Best-Performing School Systems Come out on Top. The Free Press. p. 40).

Such claims put enormous pressure on teachers, who need to adapt their pedagogy to the 21st century learning, to prepare students for continuous and self-regulated life-long learning, to help them become able and willing to collaborate with others, and also well-informed and well-networked citizens. Teachers too need to embrace life-long learning skills and

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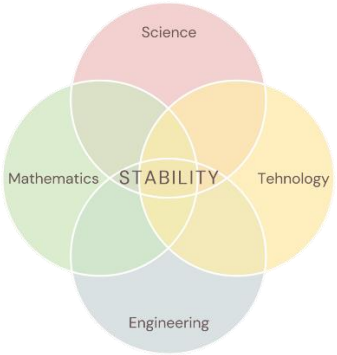
dispositions. Many of these educators may not have received adequate training in using technology in the classroom, and professional development opportunities are essential. Providing ongoing support and training for teachers helps them stay abreast of technological advancements and effectively incorporate digital tools into their teaching methodologies.

Another challenge schools and educational institutions often face is related to the technical infrastructure needed for seamless integration of technology. The use of digital resources in STEM classrooms can be impeded by outdated hardware, limited bandwidth and unreliable internet connectivity. It is therefore crucial that schools invest in robust technical infrastructure in order to ensure a smooth technological integration.

It must also be mentioned that, sometimes, teachers struggle to adapt existing STEM curricula to incorporate the latest technological tools and advancements, since the rapid evolution of technology can outpace the development of educational curricula.

- **Conclusion**

Why is STEM important? The global economy is changing. Current jobs are disappearing due to automation and new jobs are emerging every day as a result of technological advances. The continual advances in technology are changing the way students learn, connect and interact every day. Skills developed by students through STEM provide them with the foundation to succeed at school and beyond. Moreover, employer demand for STEM qualifications and skills is high, and will continue to increase in the future. Currently, 75 per cent of jobs in the fastest growing industries require workers with STEM skills.



In the digital era, where technology is at the forefront of nearly every industry, STEM education equips students with the skills necessary for success in the workforce. Proficiency

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in coding, data analysis, and technology literacy becomes increasingly important, and STEM education ensures that students are well-prepared for the demands of the modern workplace. Therefore, it is no surprise that nations with a strong focus on STEM education tend to be more competitive in the global arena. A well-educated STEM workforce contributes to economic growth, technological advancements, and innovation.

Moreover, STEM education encourages an interdisciplinary approach, breaking down traditional barriers between subjects. Students learn to integrate knowledge from various disciplines, mirroring the interconnected nature of real-world challenges. This interdisciplinary learning not only enhances the depth of understanding but also prepares students for the diverse and dynamic nature of modern careers.

Last but not least, STEM fields have historically faced issues of underrepresentation, particularly concerning gender and minority groups. STEM education initiatives strive to address these disparities by promoting inclusivity and diversity. Encouraging students from all backgrounds to engage in STEM subjects ensures a broader range of perspectives and ideas, fostering a more inclusive and equitable society.

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