Current Science Research Bulletin
Volume 02 (04), April 2025, pp. 116-121
CrossRef DOI: 10.55677/csrb/03-V02I04Y2025
Available on: https://csrbjournal.org/index.php/csrb
e-ISSN: 3050-7103
p-ISSN: 3050-709X

STEM Education in Training the Digital Economy Specialists

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ABSTRACT: STEM (Science, Technology, Engineering, and Mathematics) education is increasingly recognized as important in training professionals capable of working in the digital economy. The digital economy is generally perceived as an economic system in which the main economic processes (production, exchange, consumption) are organized using digital technologies, the Internet, and data. It is based on the use of electronic platforms, artificial intelligence, Big Data, cloud computing, blockchain, the Internet of Things, etc. Integrating STEM principles into educational curricula aims to foster IT innovation, problem-solving skills, and adaptability, which are essential for success in a technologically changing landscape, and accordingly, STEM education can be the foundation for successful undergraduate preparation in economics for the future. This article analyzes the possibility of training future economists through STEM education. The study is based on the use of theoretical methods of scientific knowledge: generalization and systematization of sources about STEM education, its impact on the development of professional competencies (knowledge, skills, abilities) of future economists; comparative analysis to study the international experience of using STEM education in the training of future specialists in the field of economics. It is shown that economics, in its essence, involves the analysis of complex systems, the interpretation of data, and the development of models for understanding and predicting economic behavior. These tasks require a solid foundation of quantitative and analytical skills, the formation and development of which are provided by STEM education. The article analyzes how integrating business principles into STEM education can contribute to developing entrepreneurship and skills in finding innovative solutions among students. It is concluded that incorporating digital technologies, cooperation between stakeholders, and a focus on continuous improvement will be key to increasing the effectiveness of STEM education in economic training and forming a skilled workforce capable of stimulating innovation and economic growth.

KEYWORDS: future economists, digital economy, professional training, STEM education, education.

PROBLEM STATEMENT

In today's world, where technology is becoming the main driver of economic development, and digitalization covers all spheres of life (Semenikhina et al., 2022b), there is an urgent need for specialists of a new type. They must combine deep technical knowledge with innovative thinking and the ability to adapt to rapid changes and transform ideas into real solutions. This is where STEM education (Science, Technology, Engineering, Mathematics) comes to the fore — an integrated approach that prepares specialists for the challenges of the digital economy.

The digital age requires the ability to program or experiment in the laboratory and an understanding of interdisciplinary connections, the commercial application of technologies, and the management of innovative projects. Traditional economic education often lags behind market dynamics, so the integration of STEM methods together with elements of entrepreneurship, artificial intelligence, and robotics becomes key to training competitive specialists.

ANALYSIS OF CURRENT RESEARCH

The digital economy is generally perceived as an economic system in which the main economic processes (production, exchange, consumption) are organized using digital technologies, the Internet, and data. It is based on the use of (Kovalchuk et al., 2023): electronic platforms, artificial intelligence, big data (Big Data), cloud computing, blockchain, Internet of Things (IoT), etc. The main characteristics of the digital economy include digitalization business processes, data orientation, network organization, speed of innovation, and globality (Fig. 1). Therefore, a workforce that owns IT technologies is needed, which is necessary for STEM.

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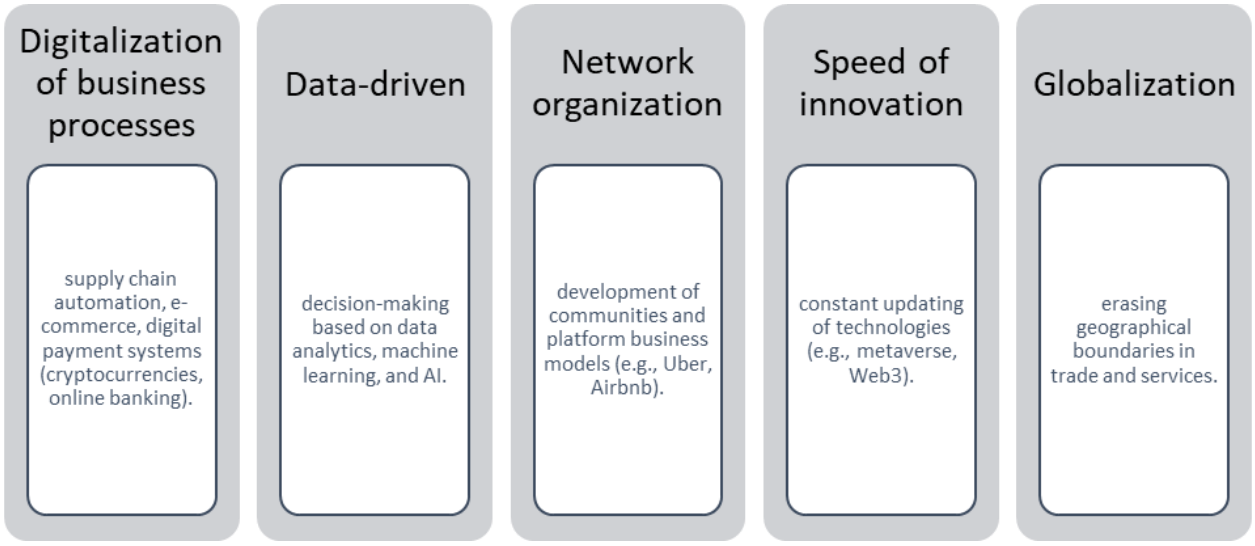

Fig.1. Leading characteristics of the digital economy

The digital economy is characterized by rapid technological progress, which requires professionals to be adaptable and able to learn throughout their lives (García-Pérez et al., 2021). STEM education encourages a mindset of continuous learning and adaptation, providing opportunities for individuals to acquire new skills and knowledge throughout their careers. This is important to remain competitive in an ever-evolving job market. As stated in (Yaki, 2022), STEM education emphasizes the development of critical thinking, problem-solving skills, and analytical skills of specialists. Such skills are essential for understanding the complexities of the digital economy, where professionals must be able to analyze data, identify patterns, and make informed decisions.

Each approach has its strengths and limitations, and it depends on integrating STEM disciplines into existing educational programs. Thus, technologies cover the theoretical and practical components of professional training using specialized technological equipment, in particular digital tools and information systems (Yurchenko et al., 2023). Another approach noted by scholars is interdisciplinary (White & Delaney, 2021). Real-world, project-based, and problem-based learning approaches, supported by community and industry participation, are particularly practical in an educational environment through proactive preparation for a future profession.

Inquiry-based learning is a student-centered approach that encourages active exploration and discovery (Hrynevych et al., 2021). Students develop critical thinking skills and a deeper understanding of the STEM concept by participating in inquiry-based activities. Digital tools can significantly support inquiry-based learning, provide students access to information and resources, and foster collaboration and communication. The information-digital approach described in (Hrynevych et al., 2021) emphasizes using digital tools in STEM education. These tools can increase students' motivation, broaden their experience, and speed up their learning of subjects. A STEM education ecosystem with digital resources can support students in various environments, making learning more engaging and productive.

There are positive practices in implementing STEM ideas in economic education. In particular, accounting education can benefit from integrating STEM principles, as noted in (Adebiyi et al., 2023). Research (Zilouchian et al., 2024) analyzes the development of financial literacy, and another study (Craft et al., 2024) studies the development of project management skills based on STEM. Approaches to active economic learning based on requests contribute to developing skills for solving real problems, are analyzed (Ješková et al., 2022). At the same time, the generalization of scientific research results shows that only isolated studies reveal STEM education as a possible way to train future economists.

The article aims to substantiate the possibility of training future economists through STEM education.

METHODS

The study required the use of theoretical methods of scientific knowledge: generalization and systematization of sources on STEM education, its impact on the development of professional competencies (knowledge, skills, abilities) of future economists; comparative analysis to study the international experience of using STEM education in the training of future specialists in the field of economics.

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RESULTS

Let's substantiate the possibility of training future economists through STEM education.

STEM education, encompassing science, technology, engineering, and mathematics, is increasingly recognized for its crucial role in developing a globally competitive workforce (Kayan-Fadlelmula et al., 2022). While the principles and skills developed through STEM education have traditionally been associated with science and technology fields, they are highly relevant and beneficial for economists early in their careers.

At its core, economics involves analyzing complex systems, interpreting data, and developing models to understand and predict economic behavior. These tasks require a solid foundation of quantitative and analytical skills, which STEM education is intended to provide.

Mathematics forms the basis of economic analysis. Economists rely heavily on mathematical models to represent economic phenomena, test hypotheses, and make predictions. A thorough understanding of calculus, linear algebra, differential equations, and optimization methods is essential for the in-depth study of economics and economic research. STEM education provides students with thorough training in various mathematical areas, ensuring their readiness to solve quantitative problems in economics. On the other hand, statistics and econometrics are also indispensable tools for economists. They allow you to analyze data and identify patterns (Semenikhina et al., 2022a) and check the validity of economic theories. Therefore, it can be considered that STEM education equips students with the statistical skills necessary to conduct empirical research, interpret statistical results, and draw meaningful conclusions based on empirical data.

In addition to mathematical and statistical knowledge, STEM education develops critical thinking and analytical and problem-solving abilities, which are valuable in economics. STEM disciplines often focus on logical reasoning, abstract thinking, and the ability to break down complex problems into manageable components. These abilities are essential for future economists who must analyze complex economic issues, identify root causes, and develop practical policy solutions.

STEM education promotes adopting a systematic and science-based approach to problem-solving. Students learn how to formulate hypotheses, design experiments, collect and analyze data, and draw conclusions based on empirical data. This scientific approach is essential for economists, who must assess the effectiveness of economic policies, assess the impact of external shocks, and make informed recommendations based on careful analysis.

In today's data-rich world, computational and technological skills are becoming increasingly important for economists. The ability to work with large data sets, use statistical software packages, and develop computational models is essential for conducting various economic research and predictive analysis. STEM education provides students the necessary skills to use technology in financial activities. Understanding the technological state of innovation is essential for economists to master the digital economy and its tools. STEM education provides insight into the workings of technology, allowing economists to analyze the economic implications of technological progress and develop appropriate policies to promote societal development (Adebiyi et al., 2023).

Integrating business principles into STEM education can contribute to developing entrepreneurship and skills in finding innovative solutions among students (Ewim, 2023). By understanding the principles of business and entrepreneurship, students in the process of STEM education can transform their knowledge into products and services (Table 1), which will stimulate economic growth and create new opportunities for the development of society—an economy where innovation is a key success factor.

Table 1. Business principles and STEM education

Direction	**Principle**	**Commentary on how STEM education fosters entrepreneurship**
Market and customer orientation	The principle of taking into account the need and demand (the development of products/technologies should take into account the needs of consumers and market demand)	Students learn not only to create technologies but also to analyze whether they will be in demand. This forms a productive mindset and reduces the risk of creating unnecessary decisions
Business modeling and monetization	The principle of analysis of sources of income and expenses (training in building business models (for example, according to the Business Model Canvas template), analysis of sources of income, costs, and value for the client)	STEM specialists will be able not only to invent but also to understand how to turn an idea into a profitable business
Agile and Lean approaches	The principle of efficient use of resources (using methodologies of rapid development (Agile) and efficient use of resources (Lean Startup).	Students learn to test hypotheses, iteratively improve products, and avoid wasting costs, which are key skills for startups

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Direction	**Principle**	**Commentary on how STEM education fosters entrepreneurship**
Teamwork and leadership	The principle of interdisciplinary cooperation (project implementation requires interdisciplinary cooperation)	STEM projects often require interdisciplinary collaboration (engineers, programmers, marketers). Soft skills (communication, negotiations, management) necessary for managers of innovative companies are developing
Financial literacy and investing	The principle of budgeting and investment search (understanding of the basics of budgeting, investment search (venture capital, grants)	Future economists will learn how to raise funds for the development of their ideas, assess the profitability of projects
Intellectual property and legal aspects	The principle of integrity in business (patents, copyrights, technology licensing)	Protecting your developments allows you to commercialize them and avoid copying by competitors
Pitching and presentation skills	The principle of a practical idea (ability to effectively present an idea to investors or clients (elevator pitch, demo days)	Without the ability to persuade, even ingenious technical solutions can go unnoticed

The combination of STEM with business approaches transforms students from "technical specialists" into innovative entrepreneurs capable of developing and bringing technology to market. This is especially true in Industry 4.0, where technology and business are closely intertwined.

DISCUSSION

Many economics programs recognize the importance of STEM skills for economists and include STEM-related content in their curriculum. This integration can take many forms. Many economics departments offer specialized courses in quantitative economics that focus on developing students' mathematical, statistical, and computational skills. These courses cover econometrics, time series analysis, numerical methods, and computational economics. Some universities offer interdisciplinary programs that combine economics with other STEM disciplines, such as mathematics, statistics, computer science, or engineering (Yurchenko & Semenikhina, 2023). These programs provide students with a broader and integrated understanding of economic and technological issues. Participating in research projects that involve quantitative analysis, data modeling, or computational methods can provide economics students with valuable STEM-related skills. Many economics departments offer undergraduate and graduate students research opportunities, allowing them to work alongside faculty on cutting-edge research projects.

Technology in economic education can improve students' learning experiences and prepare them for a data-driven world. This includes using statistical software packages, online modeling tools, and interactive learning platforms.

Technological advances such as automation and artificial intelligence are rapidly transforming the labor market and creating new economic opportunities and challenges (Yurchenko et al., 2023). Economists need STEM skills to understand the economic implications of a technological breakthrough, assess skills required for the future workforce, and develop policies to promote innovation and inclusive growth. The global workforce is called for constant reskilling as technological changes promote specific new skills while making others redundant (Stephany & Teutloff, 2024).

Despite the recognized benefits of STEM education, several challenges stand in the way of its effective implementation. These challenges include resistance to interdisciplinary education, limited resources, and the need for well-trained teachers. One of the main challenges is resistance to interdisciplinary education (Ewim, 2023). Traditional academic structures often prioritize individual disciplines, making integrating STEM subjects difficult. Limited resources and support can also hinder the implementation of STEM education (Ewim, 2023). This includes a lack of funding for teachers' equipment, materials, and professional development. This problem requires investments from governments, educational institutions, and industry partners. Effective STEM education requires teachers knowledgeable in STEM disciplines and pedagogical practices (Mohamad Hasim et al., 2022). Many educators lack the necessary training and support to implement STEM curricula effectively.

Among the ways to overcome these challenges, scientists note that digital technologies foster stakeholder cooperation and promote lifelong learning (Yurchenko et al., 2024). Lifelong learning is essential for success in the digital economy (Piątkowski, 2020). STEM education should encourage continuous learning and adaptation, allowing people to acquire new skills and knowledge throughout their careers. Online courses, professional development programs, and other opportunities can support lifelong learning in STEM disciplines (Yurchenko & Semenikhina, 2023).

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CONCLUSIONS

STEM education is essential for training future economists. By developing the necessary mathematical, statistical, analytical, computational, and technological skills, we can empower students to face the complex economic challenges of the 21st century and contribute to a more prosperous and sustainable future. STEM education can equip future economists with the skills and knowledge to solve pressing economic problems. STEM skills such as data analysis and modeling can help economists identify the drivers of inequality, assess the impact of policies aimed at reducing inequality, and develop more effective solutions. Climate change poses significant economic risks, including infrastructure damage, supply chain disruptions, and increased migration. Economists need STEM skills to model the financial impacts of climate change, assess the costs and benefits of mitigation and adaptation strategies, and develop policies to promote sustainable development. Digital integration, collaboration between stakeholders, and a focus on continuous improvement will be key to improving the effectiveness of STEM education in economic training and building a skilled workforce capable of driving innovation and economic growth.

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