European International Journal of Pedagogics

TYPE Original Research
PAGE NO. 220-225
DOI 10.55640/eijp-05-03-56

Philosophical Foundations of STEM Technologies in Modern Education

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OPEN ACCESS

SUBMITTED 29 January 2025
ACCEPTED 28 February 2025
PUBLISHED 31 March 2025
VOLUME Vol.05 Issue03 2025

Abstract: The article examines the philosophical foundations of integrating STEM technologies into modern education. Based on an analysis of the ideas of prominent thinkers in the field of education, it convincingly demonstrates the fundamental philosophical necessity of STEM implementation. It is emphasized that philosophical concepts emphasizing real-world and research-oriented learning serve as a solid foundation for the development of critical thinking, a holistic worldview, and practical skills essential to STEM. The article concludes that the philosophical conceptualization of STEM not only justifies but also strongly necessitates its integration, viewing it as a tool for fostering a harmoniously developed, creative, and adaptable individual prepared for contemporary challenges. It is emphasized that the philosophical foundations of STEM serve as a necessary methodological foundation for building a modern, effective, and humanistically oriented education system.

Keywords: STEM, Socrates, Aristotle, Plato, J.A. Comenius, R. Descartes.

Introduction: Currently, the education system of the Republic of Uzbekistan is undergoing active transformation aimed at the sustainable improvement of the quality of educational services. Special attention is paid to the continuous professional development of teachers, ensuring their alignment with current educational standards and methodological innovations. A priority direction of development is the integration of advanced educational methodologies and technologies, based on the latest achievements in pedagogical science and practice. Efforts are being made to strengthen the role of research activities in the learning environment, which contributes to the development of students' critical analysis and research skills. The active implementation of advanced digital technologies is seen

as a tool to optimize the educational process and expand access to knowledge resources. [23]

The implementation of these outlined initiatives is seen as a strategically significant element in the context of developing the intellectual potential of students, who represent the future talent pool of the nation. The ultimate goal of these transformations is to cultivate a generation of specialists with developed creative thinking, a high degree of academic independence, and competitiveness in both the national and international labor markets. [24]

In the modern educational paradigm, priority is increasingly given not only to the development of primary education, which establishes the foundation for lifelong learning and shapes the basis for an individual's further educational journey, but also to ensuring continuity and support at subsequent levels of education. Early school age is considered a sensitive period for the thorough acquisition of fundamental scientific knowledge, laying the groundwork for further cognitive development. The transformation of the educational environment during the transition to middle school involves for students the process of pursuing individual paths of self-realization, driven by their diverse interests and cognitive abilities. In this context, the pedagogical community faces a key task to prolong and intensify students' learning interest in the scientific and educational domain. It is important to emphasize that it is precisely during this age period that students should acquire the skills of critical thinking and effective application of information from diverse sources, as well as the ability to practically implement the knowledge gained. [1]

STEAM education, integrating the disciplines of natural sciences, technology, engineering, arts, and mathematics, is demonstrating a growing prevalence in modern educational systems. The implementation of such educational programs is considered an imperative, driven by the demands of the modern socio-economic paradigm and a rapidly evolving job market.

In the Republic of Uzbekistan, an active phase of education system reform is underway, encompassing both the sphere of student training and the professional development of teaching staff. During a presentation dedicated to improving the education system, held on January 26, 2024, the President of the Republic of Uzbekistan, Sh.M. Mirziyoyev, emphasized the prospects for transforming institutions for the professional development of educators. It is planned to implement specialized programs focused on the continuous professional development of teaching staff into the structure of these institutions. [24]

In his Address to the Oliy Majlis and the people of Uzbekistan, President of the Republic of Uzbekistan Shavkat Mirziyoyev emphasized that enhancing the quality of education is a key factor in the steady progress of New Uzbekistan. The modern geopolitical and socio-economic paradigm is characterized by the dominant role of intellectual and social capital in the development of nations. In light of these trends, a nation's competitiveness is primarily determined by the quality of its education system, focused on generating and disseminating relevant knowledge that meets the challenges of our time. The modern economy sees a growing demand for professionals with well-developed creative and critical thinking skills, as well as a high level of intellectual capacity. Thus, the continuous improvement of education quality is an ongoing process that directly impacts the formation and realization of the nation's human potential. [2]

In Uzbekistan, in striving to achieve the strategic goals of national development, the implementation of innovative STEAM educational technology is underway. This initiative is supported by a regulatory legal act – the Decree of the President of the Republic of Uzbekistan No. UP-79 of May 26, 2023, "On measures for the effective organization of the activities of the Ministry of Preschool and School Education and organizations subordinate to it," which designates the implementation of a set of measures for the qualitative improvement of the extracurricular education system as a priority task. [1]

In the context of the global expansion of the STEAM paradigm, the STEM concept serves as a fundamental basis, which is conceptualized by highlighting two main approaches. The first approach, referred to as "traditional," treats STEM education as a discrete set of disciplines, including science, technology, engineering, and mathematics. However, the evolution of each STEM discipline demonstrates a tendency towards the integration of elements from related fields into methodology and standards. The second approach, referred to as "integrated," is characterized by the recognition of the interconnectedness between science, technology, engineering, mathematics, and art within the framework of STEAM education. It aims to integrate these areas to create a more holistic and interdisciplinary educational experience. [3]

The discourse dedicated to the dichotomy of disciplinary and integrative approaches in education has fueled debate and disagreements within the academic community. Despite the acknowledged lack of compelling empirical evidence for inherent connections between disciplines, the challenge of balancing and preserving the authenticity of each disciplinary area has emerged. The juxtaposition of these paradigms has

served as a catalyst for discussions within pedagogical debates. [4]

A historical analysis of the evolution of pedagogical and psychological theories and concepts supports the validity of the integrative approach to education. To substantiate this position, it is pertinent to examine the historical preconditions for the formation of the integrative approach, tracing the genesis of pedagogical ideas that influenced its emergence in the contemporary educational paradigm. Within this analysis, key stages in the development of theories of elementary education, educational psychology, and collective epistemological approaches are considered, including within the interdisciplinary context of STEM education.

A historical and philosophical analysis of educational paradigms logically begins with studying the works of Socrates, Plato, and Aristotle, the classics of ancient philosophy, who formulated the key principles of education oriented towards the pursuit of knowledge as the highest good. Socrates put forward the thesis of knowledge as virtue, contrasting it with ignorance as the root of evil. He argued that the goal of educational activity lies in stimulating awareness of one's own incompetence and initiating the process of seeking truth and wisdom. As a methodological tool, Socrates proposed maieutics – a dialogical method aimed at activating critical thinking and self-analysis in learners. [7]

In the Socratic tradition, Plato founded the Academy, institutionalizing philosophical education. At the Academy, he developed and disseminated his own philosophical system, including educational ideas. Plato advocated for the principle of universal and comprehensive education for citizens of the polis, regardless of their social hierarchy. In "The Republic," he articulated an educational model based on the Athenian pedagogical paradigm. Plato viewed education as a process of harmonizing physical and intellectual development, declaring: "Gymnastics for the body, music for the soul." A key aspect of Plato's pedagogical philosophy was the recognition of the need to consider individual inclinations and interests of students, which required adapting educational methods and content to the unique needs of each student for the full realization of his potential. [8]

Continuing the intellectual tradition established by Plato, Aristotle developed and deepened his ideas. He postulated that knowledge is not only an ethical virtue but also the teleological goal of human existence. Aristotle proposed a differentiation of knowledge into three fundamental categories:

1. Theoretical knowledge: focused on understanding truth as such and is not driven by practical application. Examples include philosophy and mathematics.

2. Practical knowledge: aimed at the application of knowledge to solve specific problems and transform reality. Examples include medicine and engineering.

3. Poetic knowledge: associated with creative endeavors and the creation of aesthetic values. This category encompasses art and literature. [15]

Aristotle maintained the position that all three types of knowledge hold significance for ensuring the completeness of human existence, however, he assigned theoretical knowledge the status of the supreme good. Furthermore, he postulated the necessity of a comprehensive education, including the study of a diversified range of disciplines encompassing both the sciences and the humanities, including history, literature, and art. The intellectual legacy of Socrates and Aristotle has had a significant impact on the formation of the Western educational tradition and continues to determine the basic principles of many modern educational concepts. The conceptualization of the pursuit of knowledge as the highest value still underpins the activities of research universities to this day. This "new methodology" of education was formally incorporated into educational practice in the 13th century. [17]

In the historical context of the development of university education, religious institutions initially predominated, primarily focused on the teaching of theology, jurisprudence, and medicine. Nevertheless, under the influence of the intellectual heritage of classical philosophers, university institutions began a process of diversifying educational programs, incorporating secular disciplines such as philosophy, the natural sciences, and the humanities into their curricula.

This evolution was accompanied by the affirmation of a new educational methodology, emphasizing the significance of critical thinking, grounded in principles of rationality and empirical verification, in contrast to dogmatism and appeals to authority. This methodology also stimulated students to ask questions, explore alternative perspectives, and strive for the comprehension of truth and wisdom. Ultimately, this approach served as the foundation for the formation of the modern system of research universities, within which collaborative interaction between students and faculty is carried out, aimed at expanding the boundaries of scientific knowledge and deepening human understanding. Such a transformation marked a transition from content-oriented curricula to the concept of continuous structured learning. [12]

René Descartes, the founding father of Enlightenment philosophy, exerted a significant influence on the

formation of the epistemological foundations of modern science and laid the theoretical groundwork for the development of STEM education. Descartes postulated that the educational process should be aimed at developing critical thinking through a comprehensive analysis of various forms of knowledge, including misconceptions, in order to appreciate the value of true knowledge. He emphasized the importance of analytically examining both true and false statements to overcome cognitive biases and delusions. During the formative period of the scientific method, Descartes championed the primacy of empirical research over traditional forms of logical deduction, advancing the idea of scientific progress through experimental validation and critical analysis of the data obtained. This methodological approach facilitated the demystification not only of individual scientific discoveries but also of the processes of their conceptualization, empirical discovery, and interpretation within the framework of scientific inquiry. [19]

Descartes promoted an educational concept focused on developing critical and evidence-based thinking, challenging the notion of innate intellectual inequality. He opposed rote memorization, emphasizing the importance of intellectual freedom and the pursuit of knowledge. Descartes justified the necessity of methodological doubt and the primacy of the deductive-intuitive method of knowledge acquisition, viewing mathematics as a crucial tool for comprehending the universe. According to Descartes, education is a process of rational inquiry into the world, the foundation of which is the ability to think ("Cogito, ergo sum"). [21] He pointed out the destructive influence of childhood egocentrism on the developmental process and emphasized the importance of cultivating critical thinking and evaluative judgment. Descartes also recommended limiting the unchecked development of children's imagination, viewing it as a source of reality distortions and a potential cause of deviations from ethical norms, due to its association with egocentrism and the illusion of being unrestrained. [16]

Jan Amos Comenius, a contemporary of Descartes, posited that the purpose of education lies in preparing an individual for a fulfilling life. This paradigm broadened the horizons in the exploration of various methodologies for acquiring knowledge. By integrating the concept of life as the foundation of the educational process, Comenius initiated the development of pedagogical methods focused on active student engagement and practical application. Emphasizing the principle of observation preceding analysis, he implied the necessity of preliminary observation not only before carrying out analytical procedures, but also before defining the methodological principles of analysis. This approach became a precursor to modern scientific practices and the structuring of laboratory work in education. [11]

In J.A. Comenius's pedagogical concept, the primary stage of education was manifested as the "maternal school" (age range: from birth to 6 years). During this period, according to the educator's didactic views, the child was to carry out perceptual learning of the surrounding environment through observation of natural phenomena and sociocultural life. It was also intended to develop propaedeutic knowledge in the fields of geography and astronomy. Furthermore, Comenius emphasized the paramount importance of labor and moral upbringing as key tasks of this stage of ontogenetic development. The second stage of primary education, encompassing the age group from 6 to 12 years old, was conceptualized by Comenius as the "school of the native language." Within this educational stage, instruction was conducted in the vernacular language, which facilitated the learning of a wider range of knowledge, transcending the boundaries of the traditional educational paradigm of that historical period. The didactic initiated the inclusion of subjects in the curriculum of this school, including the study of the native language, arithmetic, basic principles of geometry, geography, fundamentals of astronomy (cosmography), as well as fundamental tenets of socio-political knowledge and craft. [10]

J.A. Comenius argued for the necessity of education based on the innate cognitive activity of learners and realized within a holistic approach. The educator criticized the disciplinary fragmentation of the educational process, asserting that the isolated study of individual disciplines reduces the effectiveness of learning due to a lack of an integrated system of knowledge. According to his didactic concept, education should promote harmonious personal development and the formation of a holistic worldview through the integration of various fields of knowledge. Comenius's ideas about the holistic organization of the educational process were a precursor to modern concepts of integrative education. [6]

The era of the 9th-13th centuries in Oriental studies is characterized as the period of the Eastern Renaissance, preceding the European Renaissance. During this period, Arab-Muslim scholars engaged in the reception of antiquity, interpreting it within the context of the Islamic paradigm. This process, despite ideological constraints, served as an impetus for the development of rationalist trends in Islamic theology.

Abu Ali ibn Sina (Avicenna), a landmark figure of

medieval thought, known in Europe as Avicenna, formulated an innovative concept of education that integrated aspects of upbringing and learning. In his view, education should encompass a broad spectrum of areas of personal development, including the intellectual, physical, aesthetic, moral, and vocational. Ibn Sina emphasized the importance of individualizing learning, proposing to focus on students' interests when developing curricula and to adhere to the principle of progressively increasing the complexity of the material. At the same time, in the initial stages of learning, he cautioned against excessive bookish orientation, prioritizing empirical knowledge. [9]

Abu Ali Ibn Sina favored a collective form of education, arguing that it creates conditions for the formation of a healthy competitive environment among students. In his view, the competitive aspect stimulates cognitive activity and enhances motivation to acquire new knowledge. Furthermore, group dynamics in the educational process contributes to minimizing expressions of apathy and inactivity, replacing them with intensive interpersonal interaction. Within the framework of collective learning, students gain the opportunity to verbalize their own ideas, participate in discussions on relevant topics, and also develop social interaction skills, including respect, mutual assistance, and the formation of positive interpersonal relationships, which, in aggregate, has a beneficial impact on the process of personal development.

In the treatise "Osoral Bokiya," Abu Rayhan al-Biruni cautioned against reducing learning to rote memorization. The scholar emphasized the importance of conceptual understanding, achieved by varying approaches to studying the subject. Al-Biruni illustrated this principle with an analogy of visiting different gardens, where each new perspective reveals unique aspects of the whole. According to the thinker, the effectiveness of memorization is due to the diversity of observed phenomena and the applied methods of cognition.

The foregoing analysis of the ideas of prominent thinkers in the field of education convincingly demonstrates the fundamental philosophical necessity of integrating STEM technologies into contemporary education. By highlighting the importance of reality-focused, inquiry-based learning, educational philosophers establish a robust foundation for the development of critical thinking, a holistic worldview, and practical skills, which are fundamental to the STEM approach. Thus, the philosophical conceptualization of STEM education not only validates, but also urgently necessitates its integration, viewing it not merely as a collection of subjects, but a potent instrument for nurturing a well-rounded, creative, and adaptable individual to the challenges of the contemporary world. It is by drawing upon these philosophical principles that we can gain a deeper understanding of the psychological mechanisms behind the efficacy of STEM technologies and design genuinely innovative and impactful educational programs. [22]

CONCLUSION

In conclusion, the philosophical underpinnings of STEM technologies are not just theoretical grounds, but constitute an essential methodological foundation for constructing a contemporary, efficient, and humanistically-focused system of education.

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