

INTEGRATION OF COMPUTER SCIENCE BASED ON THE STEAM APPROACH

Kodirova Gulrukh Hamidjonovna Teacher,
School № 20th , Bukhara

Annotation: This paper delves into the practical relevance of the STEAM (Science, Technology, Engineering, Art, Mathematics) approach in modern education, focusing on the integration of computer science with other disciplines. In today's digital era, computer science plays a pivotal role not only in teaching programming but also in developing problem-solving abilities, algorithmic thinking, and creativity. The integration of computer science lessons with subjects such as mathematics, physics, technology, and art fosters a multidisciplinary environment where students can apply their knowledge through real-life projects and interactive tasks. This STEAM-driven framework encourages collaborative learning, critical thinking, and innovation—skills essential for the 21st-century learner. The article also emphasizes how this approach increases student engagement and helps bridge the gap between theoretical knowledge and its real- world applications.

Keywords: STEAM approach, computer science integration, innovative education, problem-solving, algorithmic thinking, interdisciplinary teaching, hands-on learning, practice-based education, future-ready skills

Introduction. The Importance of STEAM Education and Interdisciplinarity. To determine the significance of STEAM education, it is essential to first focus on the core principles upon which the STEAM approach is based. One of these key principles is interdisciplinary integration, which involves the unification of knowledge from computer science, mathematics, physics, the arts, and engineering. Interdisciplinarity refers to the combination of various academic disciplines, the exploration of their intercon- nections, and the application of this integrated knowledge in practical, project-based contexts. Within the STEAM (Science, Technology, Engineering, Arts, Mathematics) framework, it plays a vital role in providing learners with complex, interconnected knowledge and skill sets.

The Connection Between Computer Science and Mathematics. One prominent example of interdisciplinarity in STEAM is the connection between computer science and mathematics. The foundational concepts of computer science are largely based on mathematics. This relationship is manifested in several key areas:

Algorithms and Discrete Mathematics – Programming is used to solve mathematical problems (e.g., Euler's or Dijkstra's algorithms).

Logical reasoning – Boolean algebra is applied in programming, particularly in conditional operations.

Graph theory – Relevant to network algorithms used in social networks and navigation systems.

Algorithm design – Programming is applied to solve mathematical problems (e.g., Euler's or Dijkstra's algorithms).

Logical reasoning – Boolean algebra (logical operations) is used in programming, especially in working with conditional operators.

Graph theory – Related to network algorithms (e.g., social networks, navigation systems).

Data Analysis and Statistics

Statistical models – Analysis of large datasets using programming languages such as Python (NumPy, Pandas) or R.

Probability theory – Applied in artificial intelligence and machine learning (e.g., Bayes' theorem).

Cryptography and Number Theory

RSA encryption – Based on prime numbers and modular arithmetic.

Blockchain technology – Involves hash functions and cryptographic algorithms.

The Connection Between Computer Science and Physics

Modeling of Physical Processes

Traffic simulation – Visualizing transportation flow in software based on physical laws (e.g., speed, acceleration).

Quantum computing – A new field combining quantum physics and computer

science (quantum bits, quantum algorithms).

Sensor Systems and Robotics

Arduino projects – Processing physical measurements (motion, temperature, light) using sensors.

Computer vision – Analyzing images based on optical laws (e.g., with OpenCV).

The Connection Between Computer Science and Engineering

Software Engineering

IoT (Internet of Things) – Smart home systems, automotive diagnostics.

Automation systems – CNC machines and robotics control.

Integration of Hardware and Software

Microcontrollers – Projects using Raspberry Pi or Arduino (e.g., a weather station).

3D printers and CAD software – Engineering design integrated with programming (e.g., AutoCAD, Solid- Works).

The Connection Between Computer Science and Arts (Digital Arts)

Computer Graphics and Animation

3D modeling – Creating animated films using tools like Blender or Maya.

Web design – Developing interactive interfaces with CSS and JavaScript.

Game Development and Virtual Reality (VR)

Unity or Unreal Engine – Game development incorporating physics (e.g., gravity, collisions).

VR/AR technologies – Presenting art exhibitions in virtual environments.

Examples of Interdisciplinary Integration

Project: “Smart Home” System

Computer Science – Python programming.

Physics – Motion and temperature sensors.

Engineering – Control via Arduino.

Art – User interface design (UI/UX).

Rapid advancement of innovative technologies, such as artificial intelligence,

programming, and robotics, and their integration into daily life require the adoption of new approaches in modern education, in particular the implementation of the STEAM model (Science, Technology, Engineering, Art, Mathematics) [3]. In this process, the subject of informatics plays a central role. Through informatics, students can acquire not only algorithmic thinking, but also important competencies such as technological literacy, digital culture, and project-based learning [4]. The STEAM approach, by integrating informatics with mathematics, physics, technology, and even the arts, contributes to developing students' ability to identify, analyze, and solve real-world problems through innovative methods [5]. Applying this approach in primary and secondary education reveals the theoretical, practical, creative, and multidisciplinary potential of the informatics subject. In particular, during informatics classes, students deepen their knowledge through activities such as designing interdisciplinary projects, creating software interfaces, coding, and controlling electronic devices, all of which are carried out in integration with other subjects [6]. When teaching programming, robotics, and artificial intelligence, the practice-oriented approach uses project-based learning, which allows students to gain knowledge through hands-on experience. Project-based instruction in robotics, artificial intelligence, and programming is a component of practice-oriented education. Practical abilities are becoming more and more important in today's classrooms than just theoretical knowledge.

Practice orientation is one of the main tenets of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. With this approach, students can learn about programming, robotics, and artificial intelligence both conceptually and practically through practical projects. As a result, students acquire knowledge as well as critical thinking, creativity, and teamwork abilities.

Methods

At the same time, existing studies show that the integration of the informatics subject based on the STEAM approach has not yet been widely implemented in educational practice. In most cases, informatics is taught separately and abstractly, which limits the opportunities to connect the subject to students' everyday lives and

other disciplines. This article aims to fill this gap by examining methodological approaches aimed at developing students' digital skills through the integration of informatics with other natural and social sciences. Within the scope of the study, lessons, observations, interactive methods, and the results of project-based activities conducted with 5th to 8th-grade students in the Tashkent, Bukhara, and Surkhandarya regions are analyzed. Based on experiments, students' motivation, their level of understanding of interdisciplinary connections, and their practical thinking abilities are examined.

Stages of Skill Development

Skill development within STEAM education is carried out in three main stages:

Programming – Developing algorithmic thinking, writing code, and debugging.

Engineering – Designing hardware and controlling it through software.

Creativity – Designing projects and generating unconventional solutions.

Given the importance of vocational preparation, these stages help students acquire essential skills for future careers such as software developer, data analyst, and AI specialist.

Project-Based Programming Education

Programming is taught through two levels of project-based activities:

Basic Projects (Introductory Level)

"Calculator" – A simple application that performs mathematical operations using Python or JavaScript.

"Correct Answer Game" – An interactive quiz program that engages with the user.

Advanced Projects (Intermediate to Advanced Levels)

"Chess Program" – A computer opponent powered by basic AI logic.

"Website Development" – Creating a portfolio or blog using HTML, CSS, and JavaScript.

Open-source collaboration – Contributing to public codebases via GitHub.

Robotics and Practical Experience

Hands-on robotics involves both building and programming robots, as well as applying them in real-world scenarios:

Robot Building and Programming

Creating simple robots using LEGO Mindstorms or Arduino (e.g., a line-following robot).

Working with sensors – detecting distance, temperature, and light to analyze the environment.

Real-World Applications

"Smart Agriculture" – An automatic irrigation system based on soil moisture sensors.

"Automated Parking" – Parking a vehicle using ultrasonic sensors.

Artificial Intelligence and Machine Learning Projects Beginner AI Projects

"Chatbot" – Developed using Python and NLP libraries (e.g., NLTK, TensorFlow).

"Image Classifier" – Built with a Convolutional Neural Network (CNN) to recognize animal species.

Big Data and Advanced AI Projects

"Medical Diagnosis Model" – Predicting diseases based on symptoms.

"Language Translator" – Translating text using neural networks.

Result

The expected results indicate that the integration of informatics within the STEAM approach enriches the content of students' learning activities, ensures greater engagement during lessons, and helps to develop essential skills needed for future careers. [10]. Through practice-oriented teaching methods, students actively engage in learning fields such as programming, robotics, and artificial intelligence.

Project-based learning provides them not only with technical skills but also enhances creativity, teamwork, and problem-solving abilities.

The STEAM (Science, Technology, Engineering, Arts, Mathematics) approach is considered one of the most effective methods for improving the quality of

education and preparing future professionals.

Discussion

Students' engagement and learning results are greatly improved when practice-oriented methodologies are incorporated into STEAM education. Students are better able to make the connection between theory and practice by concentrating on real-world applications through project-based learning. In addition to expanding your knowledge of topics like programming, robotics, and artificial intelligence, this helps you develop critical thinking, creativity, and teamwork, all vital skills for the 21st century. The growth of interdisciplinary thinking is one of the main advantages noted. Students naturally apply knowledge from several disciplines when working on STEAM projects, such as physics in robotics, art in user interface design, and mathematics in algorithms, leading to a more comprehensive grasp of complicated issues.

Additionally, the project-based approach boosts learning ownership and motivation. When students realize how their work relates to real-life scenarios and potential career paths, they are more inclined to take initiative, consider creative solutions, and engage in thoughtful problem solving. In summary, practice-oriented education within the STEAM framework holds great promise in equipping students with both technical expertise and transferable soft skills. As the demands of the modern workforce continue to evolve, educational systems must adapt by prioritizing methods that prepare learners not only to consume knowledge but also to create and innovate within their chosen disciplines. These approaches help foster future-ready skills essential for success in the 21st century job market.

Conclusions

This study demonstrates that a practice-oriented approach in teaching programming, robotics, and artificial intelligence within the STEAM framework significantly enhances students' motivation, creative thinking, and problem-solving skills. By integrating interdisciplinary connections, particularly between computer science and mathematics, students not only acquire technical competencies but also develop critical soft skills such as teamwork and innovation. In conclusion, STEAM

education, with its emphasis on practical application and interdisciplinary integration, provides a solid foundation for preparing future specialists in technology-driven industries.

Data Availability Statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Conflict of Interest

The author declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References:

1. Abdullaev A.D., Sobirov F.R. (2023), Title of the article, Journal Name, 15(5), 970-973. <https://doi.org/10.6342/ol.40.202124>
2. Bers, M. U. (2018). Coding as a Playground: Programming and Computational Thinking in the Early Childhood Classroom. Routledge.
3. Usmanov N., Khojayev B. Modern educational technologies. – Tashkent: Science and Technology, 2021.
4. Solihova M.Kh. Improving the effectiveness of education based on the STEAM approach. – Journal of “Educational Innovations”, 2022, No. P. 45–49.
5. Khodjayev B. et al. Teaching methods based on digital technologies. – Tashkent: Economics-Finance, 2020.
6. Yakubova M. Interactive approaches in computer science education. – Journal “Information Technologies and Education”, 2021, No. 4. – P. 22–27.
7. Beers, S.Z. (2011). 21st Century Skills: Preparing Students for a Global Society. National Association of Secondary School Principals.
8. Quigley, C. , Herro, D. (2016). Supporting teachers in pedagogical change: STEAM and 21st century learning. Journal of Science Education and Technology, 25(1), 117–127.
9. Yakman, G. (2008). STEAM Education: An Overview of Creating a

Model of Integrative Education. Virginia Polytechnic Institute State University.

10. Bybee, R.W. (2010). Advancing STEM Education: A 2020 Vision. *Technology and Engineering Teacher*, 70(1), 30–35.
11. Resnick, M. (2017). *Lifelong Kindergarten: Cultivating Creativity through Projects, Passion, Peers, and Play*. MIT Press.
12. Yakman, G., Lee, H. (2012). Exploring the Exemplary STEAM Education in the U.S. as a Practical Educational Framework for Korea. *Journal of the Korean Association for Science Education*, 32(6), 1072–1086.
13. Beers, S. Z. (2011). 21st Century Skills: Preparing Students for THEIR Future. *Kappa Delta Pi Record*, 47(1), 8–12.
14. Martinez, S. L., Stager, G. (2013). *Invent to Learn: Making, Tinkering, and Engineering in the Classroom*. Constructing Modern Knowledge Press.