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Modern Pedagogical Approaches to Teaching Computer Science in Primary School

Summary

The article analyzes modern pedagogical approaches to teaching computer science in primary school, emphasizing their potential for modernizing the content and organization of the educational process. The relevance is determined by the need to develop pupils' digital literacy and twenty-first-century skills in the context of the rapid digitalization of society. Computer Science is considered a space for the formation of information culture, algorithmic thinking, creativity, and collaboration. The competence-based, activity-based, learner-centered, systems approach, microlearning, problem-based, inquiry-based, project-based, flipped learning, integrative, CS Unplugged, gamification, and BYOD approaches are outlined as effective strategies for developing digital competence and lifelong learning skills.

Keywords: primary education, digital literacy, integrative approach, microlearning, flipped learning, Computer Science Unplugged, gamification, Bring Your Own Device

1. Introduction

In the context of society's digitalization, Computer Science in primary school plays a key role in developing fundamental skills needed for further learning and living in a technology-rich environment. It is an essential component of the STEM cluster, forming the basis for algorithmic thinking, information literacy, and effective use of digital tools in learning and everyday activities.

The "Education 4.0" concept emphasizes integrating knowledge with practical skills, creativity, critical thinking, and collaboration. Identifying pedagogical approaches that meet contemporary needs is particularly important in primary school, where the foundations of digital literacy are laid and pupils develop skills for independent, responsible use of information and readiness for further learning in a digital environment.

The aim of the article is to identify the potential of contemporary teaching approaches for modernizing the content and organization of Computer Science instruction in primary school.

2. Research methodology

The study employed bibliographic analysis, comparison, and synthesis of scientific sources on teaching approaches in primary school. A substantial number of recent publications were reviewed, which made it possible to identify the main approaches and determine their potential for Computer Science education. The method of conceptual generalization was applied to integrate them into a coherent framework. An important component of the research is the author's interpretation of the feasibility of applying these approaches in practice, taking into account the

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age-related and cognitive characteristics of primary school pupils. This methodological design ensures the integrity and validity of the results.

3. Results

Computer Science education in primary school should go beyond merely familiarizing children with digital devices or basic software. The contemporary content should be logically integrated with children's everyday lives, as well as with their learning, research-cognitive and creative activities. This integration promotes a deeper understanding of the educational content, making it more meaningful and practical. At the center of the educational process is the ability to use them consciously to achieve specific practical goals.

In the primary school Computer Science course, it is advisable to apply a combination of pedagogical approaches that effectively contribute to the development of pupils' foundational digital literacy (Fig. 1).

The triad of competence-based, activity-based, and learner-centered approaches

The competence-based, activity-based, and learner-centered approaches form the methodological foundation of Computer Science teaching in primary school. Their integration transforms lessons into a space

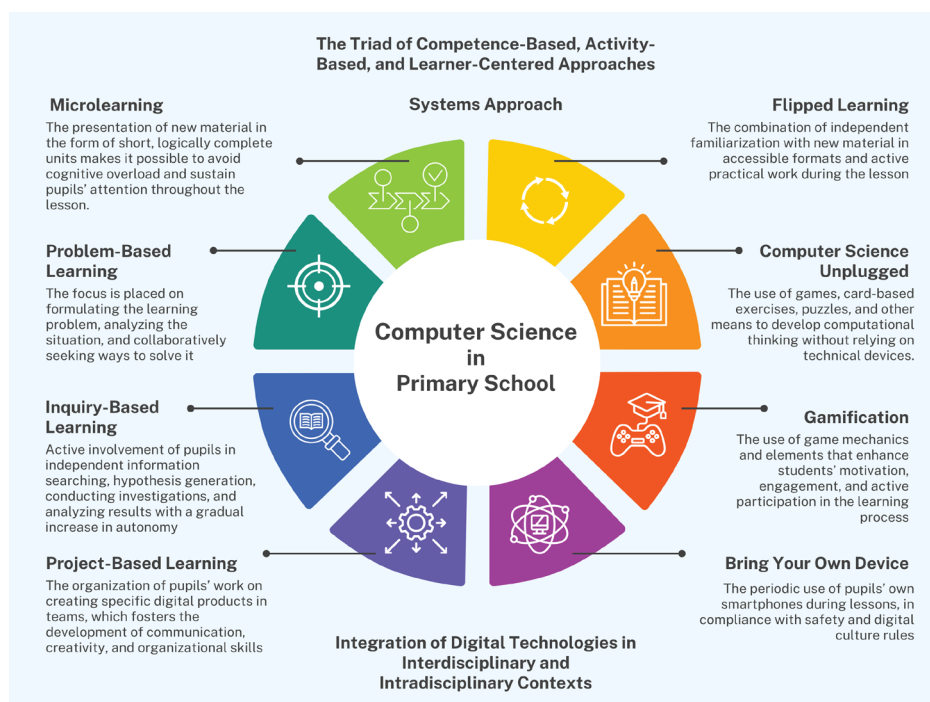
where pupils not only learn digital technologies but also develop systematic thinking, creativity, collaboration, and personal potential.

The competence-based approach (Açıkgöz & Babadoğan, 2021; Ponomariovieniè et al., 2025) focuses on applying knowledge in real-life situations. In Computer Science, this means the ability to search and evaluate information, create digital products, use tools for learning and communication, turning the subject into an environment for developing readiness to live in a digital society.

The activity-based approach (Aishatu Musa & Musa Midila, 2023; De Barros et al., 2024; Samaddar & Sikdar, 2023) emphasizes learning through action: observation, modeling, programming, and creating products. Practical tasks – from graphic editing to visual programming – allow pupils to immediately apply knowledge and gain experience that fosters computational thinking.

The learner-centered approach (Jakupcevic et al., 2021) highlights individual interests, abilities, and pace of learning. In Computer Science, it is implemented through task variability, choice of formats for presenting results, and opportunities for creativity and independence, which enhance motivation and positive attitude toward learning.

Figure 1. Approaches to Implementing Contemporary Computer Science Education in Primary School



Systems approach

The systems approach (Assaraf & Orion, 2010; Oparaji & Eziamaka, 2024) views the educational process as an integrated dynamic system with interconnected elements and developmental patterns. In primary school Computer Science, it organizes the content, forms, and methods of teaching in such a way that each learning activity is based on the previous one. Individual, pair, and group tasks, along with practical exercises, modeling, visual algorithms, and projects, promote systematic understanding. This approach helps pupils perceive task structures, establish connections, plan actions, and evaluate results, fostering computational thinking and the practical application of digital knowledge.

Microlearning

Microlearning (Dalong & Jonah, 2024; Zavodna et al., 2024) is a pedagogical approach presenting new material as concise, logically complete units that are easy to perceive, quickly learned, and immediately applied.

In Computer Science lessons, pupils' activities are structured as sequences of micro-tasks targeting specific learning outcomes: knowledge, skills, and attitudes. Short, thematically coherent lesson fragments vary in form, content, and organization, maintaining attention and stimulating engagement.

Each task involves three stages: think, act, and evaluate. Pupils understand the task, perform it, and analyze their results, fostering self-monitoring and self-assessment. Microlearning prevents cognitive overload, maintains focus, and promotes active, meaningful engagement throughout the lesson.

Problem-Based Learning (PrBL)

Problem-Based Learning (Mezak & Papak, 2019; Zakaria et al., 2025) develops knowledge and skills through analyzing and solving a learning problem. Pupils do not receive ready-made solutions; they analyze situations, ask questions, generate hypotheses, and test them in practice. In the process, they consider which actions lead to the desired outcome and justify their choices. This approach enhances cognitive activity, critical thinking, and logical reasoning, which are essential skills for mastering computer science.

Inquiry-Based Learning (IBL)

Inquiry-Based Learning (Liu et al., 2024) engages pupils' natural curiosity, involving them in formulating

questions, seeking answers, experimenting, and analyzing. In primary school Computer Science, it fosters a deeper understanding through personal research, supporting skills in information searching, data analysis, and hypothesis generation.

Activities unfold in five stages (Nguyen Thi Thu et al., 2023): Engage – the teacher poses an interesting problem; Explore – pupils experiment and record results; Explain – conclusions and concepts are clarified; Elaborate – knowledge is applied in new tasks; Evaluate – results are discussed and analyzed.

The spiral model (gradual release of responsibility) (Salehomoum et al., 2022) suggests a transition from teacher-guided inquiry to fully independent inquiry through three stages: teacher-guided collaborative question formulation, collaborative question formulation with independent answer search, and fully independent question asking and inquiry. This process develops autonomy, motivation, and competencies essential for further learning in Computer Science.

Project-Based Learning (PBL)

Project-Based Learning (Mezak & Papak, 2020; Musa & Kamal, 2024) engages pupils in creating a learning product through solving open-ended tasks. In Computer Science, this includes simple digital products such as drawings, block-based programs, mind maps, or interactive scenes. Each task has a cognitive objective and involves planning, execution, presentation, and discussion.

Teamwork is central: pupils work in pairs, groups, or as a class planning, assigning roles, coordinating actions, and discussing solutions. Projects develop communication, collaboration, critical thinking, creativity, and responsibility, as pupils learn to set goals, organize tasks, visualize and present results, and evaluate both individual and team outcomes.

Flipped Learning

Flipped Learning (Loizou, 2022; Maspul, 2023) involves familiarizing pupils with new material before the lesson, while class time is dedicated to active processing, reinforcement, and application through tasks, discussions, and teamwork. Materials may include videos, infographics, step-by-step instructions, or screenshots to allow more interaction and practical activities during lessons.

In primary school Computer Science, pupils can preview short videos, explore digital examples, or complete simple preparatory tasks, so class time focuses on creating products, solving problems, and collaborating. This approach promotes independence, application of knowledge in new situations, and teamwork skills. Success depends on teacher guidance, accessible materials, and supportive classroom conditions, laying the foundation for autonomous learning in later stages.

Integration of digital technologies in interdisciplinary and intradisciplinary contexts

Integration of digital technologies in interdisciplinary and intradisciplinary contexts (Fernández-Sánchez et al., 2022; Shvardak, 2023) is a fundamental approach in Computer Science education, which integrates learning into other educational contexts. This involves not only using digital tools in different subjects but also systematically developing digital skills in the natural environment of their application, enhancing content coherence, meaningfulness of learning, and knowledge acquisition.

Two types of integration are implemented: interdisciplinary – using digital tools in other subjects (e.g., collages in Literature, tables in “I Explore the World,” presentations on Ecology); intradisciplinary – combining Computer Science topics for practical goals (e.g., creating games or mini-projects involving text, graphics, multimedia, internet safety, logic, computational thinking, and teamwork).

This approach promotes regular reinforcement, cross-curricular thinking, reduces fragmentation, strengthens interdisciplinary connections, and enhances motivation by showing pupils the practical value of their skills. Teachers should ensure digital skills are embedded in daily learning rather than limited to a single weekly lesson.

CS Unplugged and gamification

CS Unplugged (Dağ et al., 2023; Landman et al., 2023; Yang & Kopcha, 2025) is a pedagogical approach that develops computational thinking in children without using technical devices. It employs gamification (Kaldarova et al., 2023; Riabko & Ihnatenko, 2025; Videnovik et al., 2023) through games, card exercises,

puzzles, and other materials, making learning accessible and comprehensible for primary school pupils.

This approach is particularly relevant in primary school, as prolonged computer use can reduce attention and learning effectiveness. Combining active games with logical tasks maintains interest and promotes deeper comprehension. Examples include role-playing games where a “programmer” instructs a “robot” (algorithmic thinking); card tasks for classification and grouping (generalization); pattern recognition exercises; and simplified process modeling (abstraction and systems thinking).

By integrating unplugged activities with gamification, this approach supports attention, engagement, and the development of key competencies for mastering digital technologies.

Bring Your Own Device (BYOD)

Bring Your Own Device (BYOD) (Dorris et al., 2024; Kancner et al., 2024; Kočková et al., 2024) involves pupils using their own mobile devices, mainly smartphones, during Computer Science lessons. This approach fosters a responsible usage culture and develops digital literacy in both learning and everyday life.

BYOD is applied periodically, for example, when exploring messaging apps, creating digital projects, or using interactive resources. It expands learning opportunities, personalizes instruction, and aligns lessons with the real digital environment of children. Consequently, BYOD makes Computer Science lessons more practical, interactive, and supports the development of future-oriented competencies.

4. Conclusions

The analysis of contemporary pedagogical approaches has shown that their potential for modernizing Computer Science instruction in primary school lies not only in improving teaching methodology but also in creating a new quality of the educational environment that meets the challenges of global digitalization.

The competence-based, activity-based, and learner-centered approaches provide a methodological foundation that ensures the practical orientation of learning, active student engagement, and consideration of individual needs. Their integration creates conditions for combining cognitive, motivational, and value-based aspects of learning.

The systemic approach shapes the logic and coherence of the learning process, enabling students to understand the interconnections between elements of the digital environment and transfer acquired knowledge to new situations, thereby preventing the fragmentation of the learning experience.

Microlearning optimizes lessons under conditions of limited time and high cognitive load. Its potential lies in creating a dynamic learning structure that maintains attention, develops self-regulation skills, and promotes the conscious acquisition of knowledge.

Problem-Based Learning and Inquiry-Based Learning transform Computer Science from a subject of rote knowledge acquisition into a domain of discovery and exploration. They cultivate critical and investigative thinking, the skill to ask questions, and to find well-reasoned solutions, meeting the needs of a digital society.

Project-Based Learning and Flipped Learning create conditions for deeper student interaction, develop communication and collaboration skills, and gradually foster learning autonomy, which is essential for further education.

The integration of digital technologies in both interdisciplinary and intra-subject contexts has significant potential to strengthen cross-disciplinary connections, ensure regular reinforcement of digital skills, and make learning meaningful and sustainable.

CS Unplugged and gamification maintain the interest and engagement of primary students by combining play, logic, and physical activity. They support the development of algorithmic and abstract thinking, which is especially important considering the students' age-related characteristics.

The BYOD approach expands the possibilities for personalized learning, fosters a culture of safe and mindful use of personal devices, and brings the learning process closer to children's real digital experiences.

In summary, it can be argued that the comprehensive use of modern pedagogical strategies can transform the Computer Science course in primary school from a supplementary subject into a central resource for developing digital literacy, critical thinking, and creativity. Their potential lies in creating a dynamic, integrated, and practice-oriented learning environment that prepares students for life in a digital society.

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