DIDACTIC POSSIBILITIES OF MOBILE TECHNOLOGIES IN THE DEVELOPMENT OF STUDENTS' COMPUTATIONAL THINKING

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ABSTRACT

This article discusses some learning opportunities based on an analysis of the experience of using mobile devices as a learning tool and their application in developing students' computational thinking skills. The discussion is informed by scientific, pedagogical, and technical literature on the topic. The potential of mobile technologies for the development of computational thinking among students is a crucial topic in today's education. The aim of this study is to explore this potential and its implications for teaching and learning. This study aims to investigate the impact of mobile technologies on students' development of computational thinking. The primary goal of the research is to identify the pedagogical potential of mobile devices and apps in teaching computer science and programming. The study will explore methods and strategies for using mobile technologies to foster analytical, logical, algorithmic, and problem-solving skills. The findings will inform effective approaches to incorporating mobile technologies into education to enhance students' key skills in information technology.
The primary focus of this paper is on the utilization of mobile technologies within a digital learning environment to enhance student computer proficiency. It examines various aspects, including the examination of the characteristics and context of the information society, the incorporation of digitalization into educational systems as a contemporary approach, and the attributes of mobile technologies, with specific emphasis on their significance to the methodological components of instruction and optimization of the educational process with the aim of enhancing student computer literacy through the implementation of mobile technologies.

Keywords: Computational thinking, mobile learning, mobile technologies, educational processes, mobile devices.

INTRODUCTION

The rapid development of information and communication technologies at the end of the 20th century led to the emergence of the information society, where information is the main source of economic value. This new type of society is characterized by the increasing use of digitalization, which is an integral part of the broader process of informatization. This process serves as a basis for the development of knowledge in general and in specific subject areas, such as education. The transition to digital platforms not only affects socio-economic systems, but also education systems, particularly the process of developing computer thinking among students.

Under these circumstances, there has been a shift in educational approaches, which can be defined as competency-based in this specific context. This transition to a new paradigm was due to changes in social values and the formation of a new social order for education. In industrial societies, teaching was primarily focused on preparing students for social production.

However, in post-industrial societies, the emphasis has shifted towards individual self-realization and personal career goals.

Digital technologies, in the context of the ever-changing landscape of postmodern society, allow us to optimize the learning process through methods such as mobile learning. These methods are designed to meet the unique needs of today's students.

Mobile learning is an essential component of e-learning and distance education. Thanks to portable devices, training can be conducted in a flexible manner. This means that students can gain knowledge without limitation, both in terms of time and location, through mobile learning [2].

Mobile technologies, when viewed through a didactic lens, allow us to take a new perspective on the potential of traditional teaching methods. They promote flexible (spontaneous, interactive) information exchange, the natural flow of communication (dialogue), and the hypertext organization of material in multimedia presentations. As a result, they function as an artificial cognitive system [4].

Mobile learning allows you to take advantage of the potential of digital technologies, such as independence, analytical, and predictive capabilities, in the context of artificial intelligence. This is done through web-based tasks that use OER (open educational resources) and mobile applications, as well as web platforms that utilize digital technologies (like mobile phones) to complete specific tasks throughout the learning process [8].

A web assignment is a task or activity that is posted on a learning platform and can be accessed via a web browser or a dedicated mobile application [11, 14].

The use of information and communication technologies in education allows for a more personalized approach to learning. This means that the educational process can be tailored to the needs and abilities of each individual student. This is done by creating an individualized learning path that takes into account each student's unique characteristics and learning style.
The use of IT allows for the automation of the selection of educational materials, which in turn helps to develop students' self-study skills. Access to a wide range of educational resources, both local and global, contributes to the development of critical thinking and problem-solving abilities.

In addition, the use of information and communication technology (ICT) enhances the effectiveness of the learning process. It provides immediate feedback and allows students to track their progress, which promotes active participation and increases motivation and interest in the subject.

In addition, the visual presentation of educational materials on the screen, combined with the use of audio-visual aids, enhances the overall learning experience and makes it more engaging. This approach not only enhances understanding, but also fosters creativity and critical thinking skills.

Finally, the ability to interact with and manipulate various objects using information and communication technology (ICT) gives students a more practical learning experience, further enhancing their understanding of complex concepts [12, 15, 17].

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The development of scientific and technological innovations in the field of information technology has been a significant aspect of modern society. These innovations, which have become increasingly attractive due to their advanced capabilities and easy of use, have had a profound impact on various aspects of our daily lives.

Every year, new technologies and applications are introduced to the market, leading to an increasing number of users. This is particularly true among the younger generation, who are eager to embrace these innovations. The rapid pace of technological advancement has created a culture of constant change and adaptation, as people strive to stay ahead of the curve [13, 16].

LITERATURE REVIEW

Mobile technologies are being adopted and used by society in a wide range of contexts, from daily life to various aspects of social interaction. They are employed in various fields, such as economics, business, management, and education. The range of applications for mobile technologies is continuously expanding, making them more accessible and easier to use [18].
The analysis of the concept of "mobile learning" from various sources, including the UNESCO publication and the definitions provided by I.N. Golitsina and N.L. Polovnikova, reveals a common theme in mobile learning: the utilization of mobile technologies in education. This approach is known as "mobile learning," or m-learning, and involves integrating mobile devices into the teaching and learning process, either alone or in conjunction with other pedagogical methods and information and communication technologies (ICTs) [1, 2].

According to Mora-Luis and Martin-Gutiérrez, the foundation of the digital economy is the integration of existing material production (new materials and computer-aided design and production) and digital technologies, which contribute to the widespread adoption of artificial intelligence models and the development of the internet of things. In this context, "smart products" are expected to become the norm in the future, where intelligent computerized devices, such as robots, will be able to interact with each other in the planning and execution of automated production processes. This new industrial and technological revolution presents a unique set of challenges for highly skilled professionals.

Varshavskaya, Kotyrlo, and Kuzminov argue that graduates will need a high level of computer proficiency and a thorough scientific and humanities training in order to meet the requirements of future professions. They focus on skills such as fundamental theoretical knowledge, technological skills, creativity, sociability, independence, initiative, and critical thinking.
Laos, Salvador, and Marban argue that the main goal of digital education is to cultivate an independent thinker through the development of different ways of thinking, including computational thinking.

METHODOLOGY

Mobile learning is the process of students absorbing specially organized educational materials through the use of mobile technologies and devices. This method can be defined as:
"Mobile learning is electronic learning using mobile devices, at any time and from any location, through specialized software that is based on the pedagogical principles of interdisciplinarity and modularity" [3].

Alternatively, mobile learning can be described as a method of organizing the educational process that relies on the use of mobile computing devices and wireless communications.
The use of mobile technology in education has only recently become widespread, and as a result, discussions are currently taking place about the theoretical foundations for its

implementation. The education community is exploring the potential for using mobile devices in the learning process.

Computer thinking is an approach to problem-solving, systems design, and understanding human behavior that is based on the fundamental principles of computer science. This approach includes a variety of "smart tools" that represent the breadth of the field.

Computational thinking involves recursive thinking, which is a form of parallel processing that can be described as type checking. This process involves recognizing both the advantages and disadvantages of using aliases, which can be understood as having more than one identifier for something or someone. It also includes understanding the costs and benefits of indirect addressing and procedure calls when evaluating a program.

When evaluating a program, it's important to consider not only its correctness and effectiveness, but also its aesthetics, simplicity, and elegance in design. These factors contribute to making a program more efficient and user-friendly [9].

Computational thinking is a process that involves using abstraction and decomposition to solve complex problems or design complex systems. This process involves breaking down problems into smaller parts, choosing appropriate ways to represent those parts, and creating models that help us understand the relevant aspects of a problem in order to make it more manageable.

Computer scientists use invariants to describe the behavior of systems in a concise way, and they have confidence in their ability to use, modify, and influence large and complex systems safely, without needing to understand every detail. They also design systems that work with multiple users, prefetch and cache data for future use, and consider prevention, protection against worst-case scenarios, and recovery after them.

Deadlocks, contracts, and race conditions are all related concepts in the field of computational thinking. A deadlock is a situation where two or more processes become blocked and cannot proceed, while contracts are agreements that define rules and expectations for the interaction between different components. Race conditions arise when multiple processes attempt to access shared resources simultaneously.

Computational thinking is a process that uses heuristic methods to solve problems. It involves planning, analyzing, and organizing actions in uncertain situations. This process includes searching, reorganizing, and reordering information in order to generate a list of possible solutions, strategies, or alternatives.

Computer thinking also involves considering how to make the most effective use of large amounts of data. In order to achieve the best outcome, it is essential to find a balance between various factors, such as time, space, computing power, and storage capacity.

Here are some real-life examples: When your child goes to school in the morning, they put everything they need for the day in their backpack, which allows them to pre-select and remember. If your child loses their mittens, you could suggest they follow the same route as before. When it's time to give up renting skis and buy a new pair, this is an example of an online algorithm. The queue you should stand in at the supermarket depends on the performance modeling of multi-server systems. The reason why your phone continues to work during a power outage is because of the fault independence and redundancy in the design. And using CAPTCHA to authenticate human users is a difficult task to solve for computer agents in order to prevent them from accessing sensitive information.

Computational thinking will become an essential part of our daily lives when terms like "algorithm" and "precondition" become part of our everyday vocabulary. When "non-determinism" and "garbage collection" acquire meanings that are understandable to computer scientists and when trees are represented upside down, computational thinking will be an integral part of how we interact with technology.

Computational thinking:

- **Conceptualization, not just programming:** Computer science is more than simply writing code. To think like a computer scientist means more than just being able to write computer programs;
- **Fundamental, not mechanical learning:** By "fundamental knowledge", I mean the knowledge that every person needs in order to function in modern society. "Mechanical learning" is a process that is done by machines. Ironically, it is only when our field solves the grand challenge of artificial intelligence - making computers think like humans - that "thinking" will be reduced to mechanical processes. Perhaps this can be postponed until the second half of this century;
- **The human approach to problem solving:** Computational thinking is about how people approach problems and use computers to help solve them. It's not about trying to make people think like computers, as computers can be boring and black imagination. Instead, people are creative and innovative, and with computing devices at our disposal, we can use our ingenuity to solve problems that were once unthinkable and create systems limited only by our imagination;
- **Complements and integrates mathematical and engineering approaches:** Our field of activity is inherently based on mathematical reasoning. As in all scientific fields, our fundamental principles are rooted in mathematics. Similarly, we rely on engineering methods to create systems that interact with the physical world. The limitations of basic computing devices force us to think computationally, rather than just mathematically. Our ability to create virtual worlds allows us to develop systems that extend beyond the physical realm;
- **Ideas, not products:** We not only create software and hardware that will be part of our physical world and affect our daily lives, but we also develop computational concepts that help us solve problems, manage our day-to-day lives, and communicate and interact with others;
- **It is available to anyone, anywhere and at any time.** Computational thinking will become a reality when it is so integrated into human activity that it ceases to be a clearly defined philosophical concept.

Ensuring technological development in the field of information technology and supporting the use of new digital services in various areas of activity are essential aspects of modernizing science and education in today's world. The goal of the global digital transformation of education is to effectively and flexibly implement the latest technologies to transition to a personalized, continuous, and non-linear learning experience.

The digital age demands not only new skills from school and university graduates, but also a fresh approach to preparing for future careers. This necessitates the development of relevant skills and knowledge that are in line with the demands of the digital landscape [5].

Under these circumstances, Russian and international scholars have concluded that it is essential to rethink the content, methodologies, and organizational frameworks of education. During a period of automation and globalization, the educational process must focus on addressing the challenges of socio-economic growth in light of the Fourth Industrial Revolution and the advancement of the digital economy.

RESULTS

Computer thinking in the context of digital transformation can be defined as a creative, systematic, and independent approach to problem-solving. This type of thinking involves the ability to think critically and analyze information over the long term, apply fundamental principles and accurate calculations in research, and generate innovative ideas for the future. Given the practical need to develop computational thinking skills, it is essential to organize educational initiatives that integrate sustainable development goals into real-world projects and promote them in science, industry, and other fields. These initiatives should aim to shape the thinking and information culture of members of the digital society, contributing to a more informed and innovative future [3].

Despite the numerous benefits of mobile learning, there are also some drawbacks compared to traditional in-person learning. The advantages and disadvantages of both traditional and mobile learning methods are illustrated in Figure 1.

Figure 1

Traditional education

- ✓ The teacher's ability to react quickly to student actions.
- ✓ Establishing strong emotional, interpersonal, and personal connections among participants in the learning process.
- ✓ The ability to receive feedback from teachers anytime and anywhere.
- ✓ Limits on time spent talking with the teacher.
- ✓ Lack of access to published educational materials.
- ✓ Low level of personalization and a standardized educational approach for all students.
- ✓ Limited communication opportunities.
- ✓ The delay in the teacher's reaction to online communication.

Education based on mobile technologies

- ✓ Interactive interaction with e-learning content.
- ✓ Increasing the level of personalization by using various types of mobile devices.
- ✓ Using the internet for a wide range of communication purposes, such as accessing educational materials, communicating with teachers and peers, and participating in online discussions.
- ✓ A high level of student involvement in the educational process, which can lead to better understanding and retention of material.
- ✓ The indirect formation of personal relationships between students and teachers, as well as between students themselves.
- ✓ Predefined responses from the electronic resource in response to the actions of students, such as providing feedback, grading assignments, and providing additional resources.

Figure 1. Advantages and disadvantages of traditional education compared to learning based on mobile technologies

It is beneficial to utilize both traditional and mobile learning approaches, as they complement each other and help overcome their respective limitations. This allows for the utilization of blended learning technologies, which in turn fosters the development of skills in independent learning, teamwork, and collaboration.

The use of blended learning technologies allows for a wide range of learning tools to be used, depending on the subject being taught. This is due to the three key aspects of blended learning implementation [6]:

1. The administration of an educational institution supports the implementation of an e-learning strategy. This includes the organization of training for teachers in information and communication technologies (ICT), as well as the development of incentives and rewards;
2. Technological and software support for the educational process, as well as technical support;
3. Development of teaching methods for individual subjects using a variety of pedagogical approaches, as well as the use of information technologies and active and interactive teaching methods.

The advantages of blended learning include:

- Flexibility: Each student can learn at their own pace and in a way that suits their needs;
- Personalization: The curriculum can be tailored to meet the specific needs of each student;
- Effective management: Blended learning provides tools to manage the learning process effectively;
- Reduced time and cost: Blended learning can reduce the time and cost associated with traditional training methods
- Complementarity: Blended learning combines traditional teaching methods with technology-based approaches, providing a more comprehensive learning experience;
- Social interaction: Blended learning promotes active interaction between students and teachers;
- Constant presence: A teacher is always available to answer questions and provide support;
- Accessibility: Blended learning allows for learning anywhere and anytime;
- Variety: Blended learning offers a variety of teaching methods and approaches;
- Quality: Blended learning uses more effective learning tools to improve the quality of education;
- Individualized monitoring: Blended learning enables teachers to monitor the progress of each student individually;
- Natural development: Blended learning supports the natural development of students' work and communication skills.
- The priority of student independence and self-directed learning;
- Providing personalized support to meet each student's unique learning needs;
- Organizing group training sessions to facilitate collaboration and knowledge sharing;
- Flexibility in choosing an educational path that best suits each student's goals and interests;
- Integrating a variety of educational resources, both online and offline, to enhance the learning experience.

The digital transformation of the manufacturing industry is underway, and with it come technological innovations that require training for engineering, technical, and managerial personnel to develop the qualities and skills necessary for computer thinking.

According to Zahorets, Khaskovoy, and Pank, digital resources offer more than just motivational benefits to students. The article explores the importance of using mobile applications in order to acquire a specific set of knowledge, skills, and abilities, known as "digital literacy". This process is supported by research that examines the potential of mobile devices and apps to enhance learning efficiency [7].

The history of smartphones dates back to 1992, when IBM introduced the first Simon smartphone. Since then, they have undergone significant changes and evolved into even more advanced devices. Today, it is impossible to imagine life without mobile applications. These apps have become an essential part of our daily routine, from standard apps like calculator and contacts to specialized apps for everything from fitness to gaming.

DISCUSSION

Educational games are becoming increasingly popular among users, with their popularity steadily growing. One such game, “Skazbuka”, which is designed for children aged 2-7, has over 100,000 downloads on the Google Play store. Other popular educational apps include the Multiplication Table (over 1 million downloads), and apps for learning foreign languages, science, and history (over 500k and 100k downloads, respectively).

Mobile services with educational content, accessed through special apps, are becoming more and more popular. These applications offer a wide range of benefits, such as improved learning outcomes and increased engagement. They also provide convenience for students and teachers. As technology continues to evolve, we can expect even more innovative and effective educational apps in the future.

Indeed, it is hard to imagine a modern student without a mobile device. That's why the didactic aspect, or the issue of using smartphones in an academic environment, was logical in the study by innovative teachers. A mentor at a new digital school has the opportunity to use mobile technology as a teaching tool. For instance, a teacher can use services like Quiz, Kahoot, and Triventy to assess students' performance. These tools allow students to create educational video games, quizzes, and interactive presentations independently. Students can choose relevant topics and plan their learning path by themselves. This process involves cognitive activity, such as manipulating visual images and rearranging objects on the screen [10].

We have conducted a number of studies by methodologists and researchers on the use of mobile applications in education, not only in their ready-made forms. The development of a custom-made mobile application, from problem identification to commissioning, promotes learning, cognitive development, and education in a digital school environment. Additionally, it prepares students for a successful professional career and contributes to their self-determination.

In the process of multi-stage creative activity, and in particular when teaching mathematics, it is important to apply knowledge from various fields, as well as skills in interdisciplinary communication, lean manufacturing, programming, and teamwork. Additionally, the ability to perform mathematical activities, such as mathematical literacy and mathematical thinking, plays a significant role.

During the training of engineering staff, great emphasis is placed on the significance of software and technical assistance for design and prototype development.

CONCLUSIONS

Thus, the development of mobile applications provides additional educational opportunities for training professionals in demand in the digital economy, especially in the fields of engineering and technology. The range of acquired general skills is extensive, and the importance of contributing to the development of a person's ability to formulate, apply, and interpret mathematical concepts across various fields of intellectual activity justifies the significance of this study in terms of developing the qualities and skills that underlie mathematical thinking [9].

Based on the above, it can be concluded that the introduction of new information and communication technologies into the educational process requires the implementation of certain didactic possibilities and their application:

1. Formation of ideas about functional dependence through interactive interaction;
2. Development of skills in constructing numerical and alphabetical expressions and converting them using formulas;
3. Creation of various visual representations according to specified parameters;
4. Ability to study mathematical models on screen by repeatedly changing set parameters;
5. Monitoring and self-monitoring of student learning outcomes.

The diverse didactic potential of mobile technologies makes it possible to develop a system of mobile teaching methods tailored to specific academic subjects.

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