ABSTRACT

Specialty 8D01502-Computer Science

dissertation for the degree of Doctor of Philosophy (PhD)

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Formation of computational thinking of primary secondary school students in the process of joint training in robotics

Robotics today is one of the most promising areas in the field of new technologies.It can be considered as a combination of theory and practice, computer technology, mathematics, and physics. In addition, robotics combines educational and technological vectors. Currently, domestic educational robotics is beginning to occupy a prominent and very important place in society. This, on the one hand, contributes to the development of domestic educational robotics to meet the needs of the information society, and on the other hand, creates opportunities for the younger generation to master engineering specialties in accordance with global changes in society, thanks to a focus on national technological initiatives.

In his dissertation research, R. Williams of the Massachusetts Institute of Technology proposed teaching children to understand robots as “learning” machines. When studying robotics, they rely on their ability to create their own robots.

Research on general problems of teaching robotics in higher education is published in many works. K. Mukhamedieva [1] studies the methodology of designing and implementing educational technologies in robotics at universities, and the creation of an educational environment that implements pedagogical programs for teaching robotics at universities is proposed by A. V. Petrushenkov [2] in his works. Bidaybekov E. I. [3], Bostanov B. G. [4], Dudysheva E. V. [5], Kubegenov E. S. [6], Shekerbekova Sh. T. [7] and others have analyzed the organization of educational robotics training for future computer science teachers.

Currently, teaching robotics in secondary schools is considered only as an additional subject component or as one of the elements of the computer science and technology course. The lack of a national curriculum has a negative impact on the development of robotics. Most of the current research covers general problems of robotics training. Based on individual research works, it is possible to observe the need to develop students' skills in computational thinking,

universal learning activities, and interest in technical types of creativity when teaching robotics in secondary school.

Currently, the concept of computational thinking has become widely recognized as a special direction and one of the most important elements of educational programs at various levels. The research of scientists such as Andri Ioanno [8], N. N. Kerimbayev [9], M. U. Mukasheva [10], M. Serik [11], and others is aimed at developing students' computational thinking. All types of universal learning activities are considered in the works of V. I. Filippov [12] in the process of mastering robotics. A. I. Konstantinova, in her dissertation research, asserts that interest in technical types of creativity for the development of constructive thinking can be used as software and methodological support for robotics club activities [13].

Despite the existence of separate studies in the country, the development of an evidence-based curriculum and a clear concept in the field of teaching robotics in secondary schools remains relevant. In addition, the existing methods do not provide a sufficient level of motivation for children to learn and engage in scientific and technical creativity, to work collaboratively, and do not create special spaces and forms for their intellectual development.

Consequently, there is a need to develop and present a curriculum and methodology that systematize and structure the content of teaching robotics in secondary schools. When differentiating the requirements for the content of the robotics course and comparing them with the work done to date, one can notice contradictions between them.

To solve these contradictions, students are given a research task, which is addressed by developing a methodology that forms computational thinking in joint training in robotics.

The insufficient study of this problem served as the basis for choosing the topic of this dissertation research: "Formation of computational thinking of primary secondary school students in the process of joint training in robotics."

Purpose of the study:

To offer a scientific and theoretical justification and methodology for the formation of computational thinking of secondary school students in the process of joint training in robotics.

Research object:

The robotics course in the primary secondary school.

Subject of the study:

The process of forming computational thinking when students learn robotics collaboratively.

Research hypothesis:

If we develop and integrate into the educational process a model for the formation of computational thinking through joint training in robotics, then there will be an effective formation and development of computational thinking among primary secondary school students, since technologies for organizing collaborative learning will be effectively applied.

Research objectives:

1. To determine the theoretical basis of the problem of forming computational thinking of primary secondary school students;
2. To build a model for the formation of computational thinking of primary secondary school students in the process of joint training in robotics;
3. To determine the methodological foundation for the formation of computational thinking of students in the process of joint training in robotics;
4. To conduct experimental work on the formation of computational thinking of students in the process of joint training in robotics.

Research methods:

Methods of analyzing scientific and methodological literature on teaching robotics courses in secondary schools; theoretical research on the problems of forming computational thinking; development and experimental testing of relevant educational materials and methods; conducting lessons for students; interviews with teachers, parents, and students; analysis of the experimental base; implementation of research results in the educational process of secondary schools.

Methodological basis of the study:

The research is based on the concepts of pre- and post-non-classical science, including ideas about self-organizing systems and computational thinking (Al-Jazari, Leonardo da Vinci, René Descartes, Pascal, Borelli), as well as the works of ancient and modern philosophers: Aristotle, Plato, F. Bacon, D. Hume, I. Kant; theories of human measurement systems (G. Bachelard, V. Beck, M. Weber, E. Husserl, M. Polanyi, G. Spencer).

Scientific novelty of the study:

- The theoretical foundations of the problem of forming computational thinking in primary secondary school students are determined by revealing the content of the concept of “computational thinking” and clarifying the role of robotics in its formation;
- A model for the formation of computational thinking in primary secondary school students in the process of joint training in robotics is developed, including theoretical and methodological, content, and technical-software components;

- The methodological foundations for forming students' computational thinking in the process of joint training in robotics are defined, with clarification of the prerequisites and technologies for organizing learning;
- Experimental work was carried out confirming the validity of the research hypothesis.

Theoretical significance:

The study is based on the characteristics of educational organization, the nature and structure of the learning environment using robotic systems.

Practical significance:

The results of the study are implemented in an educational and methodological complex for joint training in robotics, including the development of a program, practical manuals, and training materials. The author emphasizes the importance of developing computational thinking from primary school age using robotics as a convergence of material and information technologies.

Publications:

As a result of the study, the following articles were published: 1 article in CQASSHE, 4 articles in the Scopus database, and 2 in other publications. h-index — 5 (Scopus), 3 (Web of Science).

Research stages:

1. The first stage (2021–2022) — determination of the theoretical foundations of the research, analysis of the state of teaching robotics, and collection of student questionnaires.
2. The second stage (2022–2023) — analysis of educational programs, development of a program on educational robotics, and conducting practical classes.
3. The third stage (2023–2024) — implementation of the methodology in the educational process, conducting a pedagogical experiment, and summarizing the results.

Structure of the dissertation:

It contains an introduction, three sections, a conclusion, a list of references, and appendices.

The introduction reveals the relevance of the topic, defines the purpose, objectives, and methods of research, as well as the scientific novelty and practical significance.

In the first chapter, the concept and structure of computational thinking are considered, and a model of its formation through robotics is presented. In the second chapter, the methodology of joint learning is substantiated, methods and technologies are described, and forms of online learning are analyzed.

The third chapter describes the stages of the pedagogical experiment and presents the results of the study.
In conclusion, general conclusions are formulated.

The appendices contain programs developed during the study, methodological materials, certificates, and scientific recommendations.