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COMPUTER SCIENCE TEACHERS' PERCEPTION OF DIGITAL EDUCATIONAL RESOURCES ON ALGORITHMIZATION AND PROGRAMMING

Annotation. *Algorithmization and programming are important and necessary components of computer science education at school, which begin in the fifth grade. Online education during the COVID-19 pandemic has shown the possibilities of using digital educational resources for teaching schoolchildren. The purpose of this study is to study teachers' perception of digital educational resources on algorithmization and programming as in the case of secondary schools fifth grades.*

23 computer science teachers have been interviewed on a questionnaire including questions about the experience of using digital educational resources. The results showed a positive attitude of teachers toward the use of digital educational resources, but not everyone uses the resource as a separate learning tool. Computer science teachers have determined that a digital educational resource should include video tutorials and practical tasks related to life situations. Teachers identify different conditions for the use of resources in teaching computer science in the 5th grade. More than half of the teachers can develop a digital educational resource, but they do not use it at every lesson. Digital educational technologies can significantly increase the effectiveness of learning algorithmization and programming, which determines the importance of integrating online technologies into the teaching system in the secondary school classrooms.

Keywords: *Digital educational resources, algorithmization, Programming, Scratch, Teacher perception, computer science education*

Introduction

Algorithmization and programming are necessary elements of computer science education. In the content of computer science teaching, well-known methodologists M.P. Lapchik and E.Y. Bidaibekov identified the line «Algorithmization and programming» as one of the key basic lines that students need to be taught as early as possible [1].

Basic education in Kazakhstan begins with the fifth grade. The purpose of learning algorithmization is to acquire the skills of constructing algorithms that include the basic control structures of following, branching, and cycling. Important skills include the ability to divide a task into subtasks, to apply the method of sequential detailing

of the algorithm [2]. The methodological approach in teaching algorithmization and programming is to use performers in and without a setting [3]. Kazakh schools use block programming, which turns into text programming using Python.

The use of digital educational resources of online technology in teaching programming improves the quality of training, and motivation promotes the development of project skills and teamwork [4, 5, 6, 7, 8]. The quarantine period has shown the possibility of using digital educational resources (DER) in the educational process, however, in the post-quarantine period, the use of DER is optional.

This study focuses on teachers' perception of the algorithmization and programming DER and their use in post-quarantine time.

Training in algorithmization and programming is closely related to the concept of computational thinking, which is studied and evaluated in the framework of the PISA international testing [9]. At present, programming teaching has been introduced all over the world for primary and secondary school students to develop computational thinking skills that go far beyond programming training.

According to C. González-González [10], it is necessary to recognize that teaching programming is integral in modern education, since schools should prepare young people to work in a virtual environment. It is important that they master a modeling and programming language so that they do not become illiterate. Therefore, school education should develop computational thinking skills of young people. Until now, the emphasis has been on teaching users existing computing tools. However, this is not enough, because the modern world requires a new way of thinking and solving problems – computational thinking. Therefore, students should be taught a new paradigm of computational thinking so that they become creators of new technologies, and not just users.

According to the definition by J. Wing [11], computational thinking is a general approach to problem-solving that is applied in a wide range of STEM disciplines and more. The exact definition of the concept is still being discussed in the scientific literature, but in general, scientists agree that computational thinking skills include algorithmic thinking, working with abstractions at different levels, decomposing a problem into smaller parts, data processing, and modeling. Computational thinking develops both with and without computers, but it is often implemented through programming, as it contributes to the abstraction underlying computational thinking.

In the fifth grade, the study of algorithmization and programming begins with the study of types of algorithms, then performers are studied in the setting [1, p. 124; 12]. In the context of programming and algorithmization, the term performers in the environment (or agents in the environment) refers to entities or objects that can interact with their environment and perform certain actions based on prescribed rules or algorithms. Performers in the setting are key components in the concept of agent-based programming.

Such performers in the environment can be used to simulate and solve various tasks, such as navigating a maze, solving logical problems, or simulating the behavior of living beings. They can perform actions, change their state, and exchange information with other performers or elements of the environment [2, p. 234]. In general, the concept of performers in a setting provides an abstract model for the representation and analysis of decentralized systems where active actors interact in a dynamic environment. This allows you to research and develop various algorithms and behavioral strategies to achieve goals or solve problems.

Training in algorithmization and programming is effectively carried out using digital educational resources. DER are didactic materials in the studied disciplines and/or modules that provide training in an interactive form: photographs, video clips, static and dynamic models, virtual reality and interactive modeling objects, sound recordings, and other digital educational materials. Digital learning resources are electronic resources, such as applications, software, programs, or websites that involve students in learning activities and support the students' learning goals [13].

DER are used for education in different ways and are implemented in different forms. In traditional classes, they are used as additions to the main content of the course, while in virtual learning, digital resources actually make up the content of the class [14].

Modeling and interactive models can deepen learning and are especially useful in math and science. Graphics such as publicly available images (illustrations and photographs), diagrams, and graphs can help students better understand concepts. Videos and animations from sites like YouTube help explain the topics [15]. Digital textbooks can be used anywhere, on different devices, and they are updated faster than traditional textbooks. Online assessments, including formative and final ones, instantly provide teachers and administrators with data. In addition, they are interactive and convenient for students. Podcasts and audio increase activity and reach students of different learning styles [16].

Digital educational resources are also considered devices that are stored and accessible on a computer. DER are intended for educational purposes, have identity and autonomy about other objects, and also meet the quality standards required for electronic learning resources. L. Yang [17] reflects that these digital resources include digital video, digital audio, multi time software, websites, learning management systems, simulation programs, and resources that allow online discussions. Examples of such resources are virtual courses, educational facilities, educational games, and educational repositories, which stand out for their adaptability and the possibility of modification.

Scientists [15, p. 4043] distinguish the following types of DER: educational games, digital textbooks, mobile educational games, mobile applications for children, mobile learning applications, e-learning, learning support platforms, and e-learning platforms.

The methodological manual [18] presents digital resources used for teaching programming at school. These include the Scratch programming environment, which allows children to create their own animated and interactive stories, games, and other works, the Idol programming system designed to support elementary computer science and programming courses in high school, the Pictomir resource, Pocket Code, a Scratch-like environment for creating mobile games, a visual block programming language NetsBlox.

Various digital educational resources are used in school education in Kazakhstan [19]. Methodological developments on the BilimLand patent (bilimland.kz) are presented in an interactive format: there are video tutorials, multimedia tasks, and virtual laboratories. However, at the moment there are no digital educational resources in computer science, and in particular on algorithmization and programming. A literature review on the problem of the development and use of digital educational resources in Kazakhstan's school education has shown that this problem has not been studied enough and a more detailed study of the experience of using digital resources by computer science teachers in teaching the content line of algorithmization and programming at the basic level is required.

M.P. Lapchik highlighted the utmost importance in the correctness of the formation of the system of algorithmization concepts, the logic of teaching schoolchildren through the development of skills of managing performers in an environment, performers with parameters, to organically move on to teach «pure» programming using text in the future. Taking into account the introduction of Scratch block visual programming, a high-level Python programming language into the content of computer science teaching, researchers are faced with the task of studying the experience of teaching this content line by computer science teachers using digital educational technologies.

The effectiveness of the use of the DER depends on a number of conditions, one of the most important is the structure and content of the resource, and the methods of its use in the lesson. The main research question is to determine the perception of computer science teachers of digital educational resources on algorithmization and programming for use in the 5th grade.

Materials and methods

This study used a questionnaire with open and closed questions. The survey was distributed electronically using social networks and messengers to groups where computer science teachers are located. These groups are a community of computer science teachers formed after the thematic events at the universities of the Pavlodar region.

In the introduction to the survey, participants were asked to read a detailed explanation of the purpose of the survey, and it was explained to the participants that participation in the study would be anonymous and voluntary. Data on the knowledge

and practice of using DER were obtained from closed questions. Additional open-ended questions provided more detailed information and gave a deeper understanding of the perception of computer science teachers of the use of DER in teaching algorithmization and programming, including problems and new opportunities.

23 people participated in the survey. Eighty-three percent of the participants were women. The average age of the participants was 38 years. In order to ensure the confidentiality of participants, the questions that appeared in the survey did not require the disclosure of personal or other identifying data. The average work experience was 12 years.

The survey was distributed using Google Forms and consisted of 37 closed questions and 7 open questions, in order for the respondents to answer the question in detail (Table 1). The questionnaire included questions on the content of teaching algorithmization and programming, the structure of DER in computer science, the experience of using DER in the classroom, the role of the teacher in creating and using DER, examples of DER, and wishes for the content of DER.

Table 1. Indicators of teachers' perception of digital educational resources

Category	Question-statement
1 The content of the training	1.1 Do I need to teach algorithms?; 1.2 Programming training should start with algorithmization; 1.3 Algorithm tasks should include algorithms from life; 1.4 How do I teach algorithmization? (open question); 1.5 Do I use special resources to teach algorithmization? (open question)
2 The structure of DER	2.1 The Ideal DER includes programming videos; 2.2 The Ideal DER includes a lot of textual theory; 2.3 The DER should include more practical tasks; 2.4 Infographics are important for DER; 2.5 The DER only helps the teacher, but cannot be used as a separate resource; 2.6 The DER needs to be used independently, without a teacher; 2.7 I use a blackboard and a projector for DER; 2.8 I use personal computers for DER; 2.9 DER is adapted to the capabilities of students with special educational needs
3 DER at the lesson	3.1 The DER is used partially in the lesson (individual elements); 3.2 The DER is used completely at the lesson; 3.3 The DER should be distributed by lessons; 3.4 The DER should be distributed not by lessons, but by levels of assimilation (basic, medium, high); 3.5 I use digital technologies to evaluate learning outcomes (Google Forms, Quizlet, Kahoot, etc.); 3.6 Describe what resources you use (open); 3.7 I use resources to develop practical programming skills; 3.8 What resources do you use for Grade 5?
4 The role of the teacher	4.1 I am developing a DER for a lesson; 4.2 I use online tools; 4.3 I use programming systems; 4.4 I use shells to create DER (Articulate Storyline, iSpring, etc.); 4.5 I use at every lesson; 4.6 I use to learn new things; 4.7 I use for practical skills; 4.8 I use to assess skills; 4.9 I'm too lazy to create a DER; 4.10 I don't see the point of creating a DER when I can explain and show everything myself; 4.11 The conditions for using DER are not created at school

Continuation of table 1

Category	Question-statement
5 Experience of using DER	5.1 What should the DER for teaching algorithmization and programming for Grade 5 include? (open question); 5.2 What can be removed from DER? (open question); 5.3 What else should be used to effectively teach children algorithmization and programming in 5th grade? (open question)

In closed questions, a 5-point Likert scale was used, from a very high score to zero, associated with the consent or disagreement of the statements of the questionnaire (0 – strongly disagree, 1 – disagree, 2 – neutral, 3 – agree, 4 strongly agree).

Results

In question 1, the attitude of teachers to the algorithmization section was studied. 91.6% of teachers agree, and 8.3% of teachers disagree that algorithms should be taught. Nevertheless, teachers note that it is necessary to form the skills of algorithmization in schoolchildren before learning programming. 83.3% of respondents noted that it is necessary to start learning programming with algorithms. 16.6% disagree with this. One person does not agree that algorithmic tasks should be taken from life.

The teachers' answers to the open question «How do I teach algorithmization» showed that they use flowcharts, working examples, why it is needed and how it is used, study cycles and conditional structures (including nested ones), processing arrays, as well as working with multidimensional arrays. Some teachers note that first you need to master the theoretical foundation: the basic data structures, their properties and methods of working with them, the analysis and complexity of algorithms, their main types and classes, and then approach the solution of algorithmic problems.

Another part of the teachers pointed out that learning algorithmization and programming should start from the elementary grades, examples from everyday life are taken, after which the transition to games and «code hour» is the time for programming. Most teachers note that algorithm tasks should include algorithms from life, life situations and tasks. One teacher indicated that they start teaching with natural language, and then proceeds to flowcharts. Also, teachers use DER, textbooks, and tasks are compiled.

To the question «What special resources do I use to teach algorithmization», the respondents gave the following answers: games, only self-study, games like Minecraft, code hour, simulators like «game logo», Python programming system, resources on the Internet, scratch online, reply.it, html-online, website «Bilimland», «Onlinemektep». One teacher noted that they use A.V. Goryachev's textbook, brochures with algorithms, as well as a free database of algorithmization tasks in primary classes. Some use «game blocks». As a wish, one teacher noted: «The fifth grade is represented by the robotics section, I

would like to continue Scratch instead, but in a more in-depth form, cartoons with good use of cycles, lists, and other structures.»

The second block of the survey determined the desired structure of DER. 75% of respondents answered positively to the question «Should DER include video tutorials», 8.3% of teachers disagree, and 16.7% of respondents remained in a neutral position. Fifty percent of teachers do not agree that DER should include a lot of textual theory, 25% agree, and 25% of respondents are neutral to textual information.

At the same time, 100% of the teachers surveyed agree that DER should include more practical tasks, and 100% also agree that DER should include infographics to help teach programming.

The following results were obtained for the statement that the DER only the teacher, but cannot be used as a separate resource: 58.4% of respondents agree, 25% disagree, and 16.7% are neutral. 25% of computer science teachers do not agree that DER should be used independently, without a teacher, 33.3% agree with this statement, and 41.7% are neutral in the answer. 83.3% of computer science teachers agree with the statement «I use a blackboard and a projector for DER», 8.3% do not agree to use a projector, and 8.3% are neutral. 100% of computer science teachers use personal computers when reproducing DER. 75% of respondents agree that DER should be adapted for all users, and 25% of respondents disagree with this. The issue of accessibility of DER for all categories of students makes it possible to implement inclusive education for children with special educational needs. The research of scientists [20] presents the experience of designing a digital resource for teaching computational thinking to children with mental disabilities.

The third set of questions is related to the experience of using DER at the lesson. 8.3% of teachers disagree with the fact that DER is used partially in the classroom, 71.7% agree with this. Only 33.3% agree that DER should be fully used at a computer science lesson. 66.7% of respondents agree that DER should be distributed by lessons. The rest disagree or are neutral. 58.3% of teachers agreed that DER should be distributed by levels, of which 16.7% disagree with this statement.

All teachers among the respondents use digital technologies to evaluate learning outcomes – Google Forms, Quizlet, Kahoot, and Mentimeter use resources to develop practical programming skills (100% of respondents). An open question showed that teachers use such resources to teach algorithmization and programming: «Computer Science, Stepik, robotics programs, games like block games». Two teachers indicated the scratch learning environment itself; a book, Stepik, an electronic textbook, Python tutor, Scratch online.

The use of online resources significantly improves the quality of programming training, which is reflected in the research [21]. However, some teachers use traditional

teaching tools in the form of a book to solve a large number of practical programming problems.

75% of teachers develop digital educational resources, and 25% answered negatively that they develop digital educational resources for teaching algorithmization and programming to schoolchildren. Shells for creating digital educational resources are used for development, such as Articulate Storyline, iSpring, Active Studio, Unity, and HTML5 – 75% of the teachers use these shells, and 25% are neutral in response. 25% of the teachers surveyed use DER at every lesson, while 41.7% of computer science teachers do not use DER at every lesson, 33.3% of teachers are neutral in their response.

66.7% of teachers agree with this statement, 25% of respondents answered neutrally, and 8.3% disagree with this statement. 50% of respondents agree that they use DER for practical skills of algorithmization and programming, and 50% of the surveyed computer science teachers preferred a neutral answer.

50% of computer science teachers use DER to assess skills in algorithmization and programming, and 50% do not use it in the educational process. Of these, 8.3% indicated that they were too lazy to develop a DER.

To the questionnaire question «I don't see the point in creating a DER when I can explain and show everything myself», 8.3% of the teachers surveyed answered that they agree, 8.3% have a neutral attitude, and 83.3% disagree with this statement.

25% of computer science teachers agree that the school has not created conditions for the use of DER in the computer science lesson, 50% disagree, 25% are neutral.

Answers were received to the open question of the questionnaire «What should a digital educational resource for teaching algorithmization and programming for grade 5 include?». The teachers indicated criteria such as visibility, tasks for practicing algorithmization skills, all in the form of a game or quest; development environment and practical tasks; drawings, videos, audio, animations, links, interactive tasks; more practical material; examples, theory, practical tasks, tests; good practical tasks. The respondents practically agreed that DER should meet the requirements of interactivity and be of a practical nature.

As an extra element in the digital educational resource, teachers noted that a lot of text, lectures, and a large amount of theory can be removed from DER. As methodological techniques for effective teaching of algorithmization and programming to children in the 5th grade, computer science teachers also noted the use of flowcharts, a timer for completing tasks, online simulators, the use of game forms of learning, which correspond to the research of K. Falkner et al [21].

The results showed that teachers have a positive attitude towards the use of DER in teaching algorithmization and programming. They prefer to use gaming technologies, a large amount of practical material and tasks. At the same time, they pointed out the need

to reduce textual information in favor of solving life problems using algorithmization and programming. The studies [18, p. 264; 21, p. 401] consider game technologies that contribute to more effective teaching of programming to students.

Computer science teachers pointed out that DER contribute to the improvement of learning algorithmization and programming, indicating that this is an opportunity to improve their learning tools and expand their range. This conclusion is consistent with other studies on the use of digital educational resources, which have shown that open educational resources have allowed teachers to undergo digital transformation and find new ways of teaching and learning.

The study has some limitations. Firstly, the survey was conducted according to its own methodology with questions that were compiled by experts in the field of digital educational resources development and distance learning. The subjectivity of the questionnaire questions also affects the nature of the respondents' answers. Secondly, a small sample does not allow us to draw convincing conclusions, although the number of samples is limited by the number of computer science teachers who work in schools. Despite the limitations, the results of this study highlight the direction and content of the development of digital educational resources for algorithmization and programming of 5th grade students.

Conclusion

The COVID-19 crisis has advanced online education worldwide and has clearly shown that the use of digital educational technologies in school education is a necessity. Our research focuses on the study of the content and structure of a digital educational resource on algorithmization and programming for the fifth grade.

The results of the study allow us to conclude that it is necessary to develop digital educational resources in accordance with the preferences of teachers. Digital learning depends on teachers' conscious and experienced use of technology in their learning strategies. The attitude of teachers to digital learning should be formed in teacher training programs, both before and during operation. Our results indicate the need to develop digital educational resources based on the selected learning principles: the availability of video tutorials, the assessment of schoolchildren in a digital educational resource, the inclusion of a large number of practical tasks of a vital nature on algorithmization, and the inclusion of game practical tasks.

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Информатика мұғалімдерінің алгоритмдеу және бағдарламалау бойынша цифрлық білім беру ресурстарын қабылдауы

Аннотация. Алгоритмдеу және бағдарламалау бесінші сыныптан басталатын мектепте информатика пәнін оқытудың маңызды және қажетті құрамдас бөлігі болып табылады. Covid-19 пандемиясы кезінде онлайн технологиялар оқушыларды оқыту үшін цифрлық білім беру ресурстарын пайдалану мүмкіндіктерін көрсетті. Осы зерттеудің мақсаты жалпы білім беретін мектептердің бесінші сыныбының мысалында алгоритмдеу және бағдарламалау бойынша цифрлық білім беру ресурстары мұғалімдерінің қабылдауын зерттеу болып табылады.

Цифрлық білім беру ресурстарын пайдалану тәжірибесі туралы сұрақтарды қамтитын сауалнама бойынша 23 информатика мұғалімдерінен сұхбат алынды. Сауалнама нәтижелері мұғалімдердің цифрлық білім беру ресурстарын пайдалануға деген оң көзқарасын көрсетті, бірақ бәрі бірдей ресурстарды жеке оқыту құралы ретінде жиі пайдаланбайды. Информатика мұғалімдері цифрлық білім беру ресурсында өмірлік жағдайларға байланысты бейне сабақтар, практикалық тапсырмалар болуы керек екенін анықтады. Мұғалімдер 5-сыныпта информатиканы оқытуда ресурстарды пайдаланудың әртүрлі шарттарын анықтайды. Мұғалімдердің көпшілік бөлігі цифрлық білім беру ресурсын дамыта алады, бірақ оны әр сабақта қолданбайды. Цифрлық білім беру технологиялары алгоритмдеу мен бағдарламалауды оқытудың тиімділігін едәуір арттыра алады, бұл

жалпы білім беретін мектеп сыныптарында онлайн технологияларды оқыту жүйесіне біріктірудің маңыздылығын анықтайды.

Кілтті сөздер: Цифрлық білім беру ресурстары, алгоритмдеу, бағдарламалау, Scratch, мұғалімдердің қабылдауы, информатиканы оқыту

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Восприятие учителями информатики цифровых образовательных ресурсов по алгоритмизации и программированию

Аннотация. Алгоритмизация и программирование являются важной и необходимой составляющей обучения информатики в школе, которое начинается с пятого класса. Онлайн обучение во время пандемии COVID-19 показала возможности использования цифровых образовательных ресурсов для обучения школьников. Цель настоящего исследования является исследование восприятия учителей цифровых образовательных ресурсов по алгоритмизации и программированию на примере пятого класса общеобразовательных школ.

Были опрошены 23 учителя информатики по анкете, включающей вопросы об опыте использования цифровых образовательных ресурсов. Результаты показали позитивное отношение учителей к использованию цифровых образовательных ресурсов, однако не все используют ресурс как отдельное средство обучения. Учителя информатики определили, что цифровой образовательный ресурс должен включать видеоуроки, практические задания, связанные с жизненными ситуациями. Учителя выделяют разные условия использования ресурсов в обучении информатике в 5 классе. Более половины учителей умеют разрабатывать цифровой образовательный ресурс, однако не используют его на каждом уроке. Цифровые образовательные технологии могут значительно повысить результативность обучения алгоритмизации и программирования, что определяет важность интеграции онлайн-технологий в систему преподавания в классах общеобразовательных школ.

Ключевые слова: цифровые образовательные ресурсы, алгоритмизация, программирование, Scratch, восприятие учителей, обучение информатике