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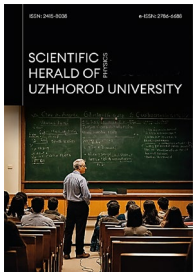

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A model for teaching students to create educational games in supplementary education in computer science

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Abstract

Relevance. The relevance of the stated topic of this research is determined by the presence of significant changes in modern educational processes, which have caused an increase in the importance of issues of digital literacy and information technology education for students at all levels of educational institutions.

Purpose. The main aim of this research is to explore the key principles of a model for teaching students how to create educational games in further education in computer science, with the programming environment Scratch selected as an example.

Methodology. The methodological approach in this research is based on a combination of the method of system analysis of the principles of using educational computer games in the educational process and a comprehensive study of the impact of game-based methods of teaching classes on students' learning of educational material. The scientific research was conducted on the basis of the Kazakh National Pedagogical University named after Abay.

Results. In this scientific study the results were obtained, indicating the existence of fundamental opportunities for students to prepare individual models of learning games aimed at stimulating their activity in the learning process, increasing their motivation and involvement in the learning process. In doing so, educational games can be used to create a quality model for the individual learner; in fact, such games provide ample opportunity for the learner to interact with the computer, which can be used in the future to develop effective educational game models when developing additional teaching methods in computer science.

Conclusions. The practical relevance of the results obtained in this research study and the conclusions formulated on their basis lies in the possibility of their application in the creation of additional game learning materials designed to develop the computer science competencies of students acquired during their studies in an educational institution.

Keywords: game-based learning; computer science; additional education; programming; Scratch.

Introduction

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The subject matter of this research study is the integration of learning programming with the use of educational games in order to find a practical tool for creating educational games in the context of further education in the field of computer science. One of the tools available in practice (discussed in this research paper) that would allow all learners to integrate easily into the process should be considered visual programming tools based on blocks. An example of this is the use of the Scratch software package, which is a block-based programming tool for creating interactive learning games and a number of other tools, without requiring the learner to know the syntax of programming languages.

M. Prensky [1], in his research on current trends in modern education, points out that one of the most significant trends observed in education is a change in students' attitudes and motivation towards learning. According to the author, a large number of today's students see education as a waste of time, and this attitude and motivation for learning is a significant concern and largely explains the current downward trend in the total number of additional courses provided by educational institutions worldwide, despite the fact that there is now a shortage of qualified engineers and scientists of all ranks in almost all countries worldwide.

The topic is developed by J.P. Gee [2], in a scientific study of the use of video games in education. The author notes that the idea of using computer games in the education system is not new, but it was negatively influenced by the concept of harmful effects of video games, which became widespread in the 1980s. However, according to the scholar, numerous studies have found that computer-assisted learning games can be successfully used to develop some cognitive abilities and improve students' understanding of topics and subjects in the curriculum of the educational institution.

At the same time, a scientific study by a group of authors, represented by J.A. Patel et al. [3], aimed at examining the vulnerability of selected social groups to COVID-19, noted that the model of student perception can be defined as "A model of human knowledge, complexity and possible delusions". According to the authors, as the student assimilates the learning material, the information is reformatted in his/her worldview model, which results in the gradual formation of a new worldview paradigm and certain beliefs in the student. The process of knowledge model formation requires constant observation of the student's interaction with the computer [4-7].

F. Heintz et al. [8] in a joint research study investigated the problematic aspects of introducing computing models in modern education. According to scholars, educational games should not only be seen as elements of interactive software that promotes student engagement and full mastery of attention, but also as a tool that provides ample opportunity for the student to work with the computer, which can be used to create reliable and more accurate models of student learning process construction. For this reason, the use of educational games (which are interactive content) to develop learner competences has considerable potential.

According to a team of authors represented by P.J. Rich et al. [9], in a joint study that addressed a number of problematic aspects in the application of current international trends in teaching, computer science education in modern schools is still characterized as "primitive", with teachers often lacking the necessary theoretical and technical knowledge in the practical application of modern technological innovations in computer science and programming. The authors point to the fact that this is due to the lack of an appropriate quality scientific basis for the implementation of programme materials in this field.

The main purpose of this research is to study the fundamental principles of creating a model for teaching students of the Kazakh National Teacher Training University to form learning games when they receive additional education in computer science, on the example of the Scratch programming environment.

Materials and Methods

The methodological approach in this research is based on a combination of systematic analysis of the general principles of educational computer games and a comprehensive study of the impact of game-based methods of teaching classes on students' understanding and comprehension of educational material. Empirical research methods were also used: experiment, description, observation. In the course of the research, the school curricula of the Informatics course and similar subjects were analysed. The curriculum consists of two parts: theoretical and practical. This programme provides for the study of "Algorithms and Executors", which takes 20 to 25 academic hours, during which students are introduced to such concepts as: algorithms, constructs, methods, and tools for creating algorithms, learning by example using a structured programming language.

Practical application of the method of system analysis of the principles of introducing computer-based learning games in the educational process in its planning involves a systematic study of learning materials, which revealed that the learning of algorithms and programming tools involves learning either a specific programming language (most often Pascal, Delphi), or an algorithmic language, which has a narrow focus.

A comprehensive study of the impact of game-based learning methods on students' understanding and perception of the learning material involves the preparation and practical use of methodological guidelines for the use of educational games implemented in the course of supplementary computer science classes.

The combination of research methods chosen led to the research being carried out in strict accordance with the following practical principles:

1. The design of the school and the classroom was carried out in such a way that all opportunities for positive, long-term contact between adults and children could be realized that can provide the necessary support for the developmental skills and free, purposeful expression of the will of the pupils.

2. The play and classroom areas were used as fully safe and comfortable for all participants in the learning process. These learning communities are fully personalised, with students feeling that they fully belong to them. Teachers took an active part in the practical sessions, allowing them to get to know their students well and to respond fully to all their learning needs.

3. Practical school sessions were focused on building mutual respect and encouraging any expression of trust among teachers, school staff and students' families, thus ensuring that the fullest possible knowledge of the children is obtained, and that family and school efforts are optimally coordinated. The use of illustrative examples and tasks increased the likelihood of gaining thorough knowledge of the field of study. This enabled the use of visual programming tools and the successful exploration of information technology. The visual programming environment Scratch was chosen for the study in order to select the necessary learning tools for further education and to determine the basics of programming in integrated visual environments. In the following steps, the basic concepts, and tools to ensure the implementation of learning to program through the creation of educational games within the framework of supplementary education are discussed.

The above-mentioned principles of scientific research made it possible to obtain objective results and draw conclusions based on them.

Results

Programming and IT training

The use of games in the learning process can be implemented in addition to commonly known teaching methods, and they can also be integrated into existing curricula to complement and optimise offline or online learning systems in practice. These options have definite advantages, which are determined by the needs of the users, and it matters whether game-based learning adds value to the learning experience or solves problems of application of human resources as well as consideration of the costs of teaching. The age of learners has a major influence on the quality of decision-making regarding the choice of a particular learning method. Game-based learning materials can be targeted or immersive [10].

Game-based early learning projects, such as BECT's Computer Games in Education (CGE) project at the Massachusetts Institute of Technology, use computer games as a supplement to the applied learning programmes. The bulk of the computer games that are used in various playful, developmental projects are designed to arouse students' curiosity and interest in order to turn them into active learners.

The play-based form of learning is attractive to students because it encourages them to explore the world of play, through which the subject matter presented in the game is explored. Qualitatively designed learning games incorporate many learning theories: multiple intelligences, operant state theory, laws of consequence, hierarchy of needs (Maslow). Play-based learning necessarily includes a number of approaches to the construction of the learning process, which have proven practical to date [11-16]. These approaches to learning include active, experiential, and situational learning.

Practical activities to develop games that the learner can put into practice in his or her own learning process emphasise the importance of the experience gained. This is how the model is used, assuming that the learning process is a sequence of alternating certain stages, which are better described as actual experience, reflective observation, abstract reflection, and an active stage involving the setting up of real-world experiments. Play-based learning encourages active experimentation by students during the learning process. The established rules stipulate the permissibility of interactivity which, by creating specific game situations, gives all participants a certain degree of freedom to interact with the objects constituting the game process directly in the game space. Every game action corresponds to certain answers, which are a form of knowledge (causality) due to the interactive perception capabilities of the game situation. This is usually achieved by a single mouse click or keystroke. In order to reinforce the skill and the usefulness and necessity of each particular action, students are encouraged to perform them repeatedly, thus building the necessary practical experience. The simplicity of the control interface (which directly incorporates the game pad, keyboard, and mouse), and the clear and straightforward answers in set game-based learning situations make it easy to perceive the results and make the game-based learning model extremely clear, objective, complete and accurate reflection of real-life events.

Scratch software package

Several simple and tentative programming environments have been created to help beginners avoid the most common mistakes, which are logical and syntactic. This is why block programming languages have been used almost everywhere instead of standard command input. In this context, all system nodes should be regarded as constituent elements of the programming language used: control structure, operators, variables, or functions. This study looks at the Scratch programming environment [17], created and presented by the Lifelong Kindergarten development team at MIT Media Lab.

Scratch is a free and open-source tool [18-19]. The software makes it much easier to create interactive stories, cartoons, games, musical compositions, and numerical simulations. This gives students the opportunity to share their creative work online. Today, Scratch has its own creative learning community, which has more than two million registered users with a large number of projects.

In essence, the development of Scratch has been implemented for learning, through exploration, experimentation, repetition of actions and immersion in the subject material. The coding blocks are built like LEGO bricks. As with toys, children can learn to create programmes and learn by simply putting the blocks together and taking them apart [20-23]. They also find new ideas by observing what others are doing and collaborating with them to do something together. The designer approach to programming in blockchain environments such as Scratch can set a negative precedent in programming practice because proper software development principles are not implemented [24-26]. The concept of "code smell" is a useful method of identifying these undesirable activities. The term "code smell" has been defined [27] and refers to a superficial indication of inaccuracies in software that usually correspond to a deeper problem.

Such features of the source code are also characteristic of the varieties of programming languages to which Scratch belongs, as it supports a constructivist approach to programming in which solutions are not planned but are

created mainly through independent research. This allows learners to create programmes quickly but can lead to the learner creating "bad" code and forming bad programming habits.

The Scratch software package can be used by teachers at Kazakh Pedagogical University as part of the school curriculum to develop presentations, tutorials and manuals showing different aspects of the teaching material. In addition, this software package can be successfully applied to the development of learning projects such as short-lived cartoons as well as interactive games. The capabilities of the software package in question allow it to be used in almost any subject area – it makes little difference which discipline Scratch is used by teachers as part of the curriculum.

Squeak was used to develop the software package Scratch. This programming language was a type of object-oriented language which theoretically allows parallel programming. The language was originally designed for practical use by students aged 8-16, as they are most attracted to the ease of scripting and the practical use of graphics, animation, audio, and video effects. This language can be learnt at primary school level and also with a significant increase in the complexity of project tasks at secondary level (with mathematical functions, computational processes, variables, lists). The programming language in question is very simple, yet accessible for self-learning by students, and includes a full set of all the relevant functions. A student learning to program and compose in the Scratch environment only needs to be able to read and have basic computer skills (in Windows).

The Scratch programming environment includes 8 different types of blocks through which object properties and methods are implemented; these objects are called "sprites". In training sessions, it is important for teachers to impart to their students the skills to implement these objects, which is extremely important in the context of their learning the basics of programming, as well as useful project skills. This can be achieved by teachers by instilling in students a real interest in learning the principles of programming using the Scratch software package, with those students who show the greatest interest being able to develop programming skills on their own, as part of individual lessons.

The study developed the methodological aspects of teaching the creation of educational games in the context of supplementary computer science education. The development of the course implied the need to create a wide range of practical guidelines for the teacher in conducting computer science lessons in the context of supplementary education course. The course includes theoretical data, laboratory practice and additional practical tasks. The aim of the course is to obtain and subsequently improve the skills of abstract, algorithmic and concrete, practical thinking of schoolchildren in the process of creative work on the creation of educational games using visual programming tools. The objectives of the course cover several areas and are divided into educational, developmental and educational:

1. Teaching assignments, which are divided into: establishing the concepts of programming, compiling program code, the relationship of code blocks and features; learning the concept of an algorithm, its features and properties, learning how to create your own algorithms; the formation and assimilation of knowledge about simple algorithmic structures that enable competent upgrading of created algorithms; analysis of data from additional sources, development of skills in structuring the information obtained.

2. The developmental tasks allow you to increase your information culture and interest and ensure that you develop the skills to apply theoretical material to practical implementation.

3. Educational objectives include the imparting of skills for independent work, responsibility, and diligence.

In addition, students should be familiar with the basic concepts and functions of Windows, Linux, Mac OS (depending on the hardware in the school) and the commands that are executed in it in order to start learning to program.

The outcome of the further education course involves students gaining the following knowledge: theoretical and practical knowledge of algorithms, basic properties, features, the ability to create and illustrate algorithms using examples; the principles of automation when executing algorithms; learning and use of algorithmic constructions (sequence, branching, loops); learning and application of visual programming skills, creating readable code; experience of applying theoretical knowledge and skills in project work. Forms of training that may be appropriate for the course being developed: group training (up to 10 people); training takes place in a computer lab, where the number of computers is set according to the total number of students; the lesson time is 90 minutes, due to the fact that it includes theoretical knowledge and practical work.

Teaching delivery methods include: explanation, demonstration, practical examples and work, laboratory work, group assignments, oral and written knowledge control, testing (exams or assessments) and project work. The course also includes students' independent research activities. The learning tools include technology and teaching and learning packages [28-31]. The academic achievement rating is based on a diagnostic approach to the assessment of knowledge, skills, and achievements, based on the completion of both mini projects in groups or individually, and large projects designed for a long execution time. The project methodology can be used to simulate a constant "situation of success" for each participant in the educational process, which contributes to a high level of motivation in learning. It is also necessary to include testing of knowledge of theory through tests and oral questions. Test projects can be developed for interim monitoring. The following points should be formulated and justified when defending them: aim and objectives of the work, analysis of successful or problematic situations in the course of the project, recommendations.

In the final stage, students prepare individual final projects. The final project may be a continuation of the test work. The final projects are presented in public, defended, and evaluated. They are assessed by an independent, competent jury, which may include schoolteachers, students, and other mentors.

Discussion

The team of authors represented by U. A. Bukar et al. [32] in a joint research study on crisis informatics in the context of current challenges, opportunities and directions came to the conclusion that in the current environment, the application of information technology for crisis management is actively developing as an independent field of research. According to scholars, social media is now widely used in crisis informatics and crisis communication, as well as in crisis management assistance and communication. The researchers' conclusions are in line with the findings of this scientific study, greatly complementing and extending them in the context of assessing the role of information technology in crisis management and the prospects for training for this kind of management action through play-based learning.

R. Jayakanthan [33], in his research on the principles of computer games in education, points out that the student model should be considered as one of the fundamental components of the intellectual learning environment. It is noted, however, that to date there is very little scientific work on modelling learners to a relatively new type of pedagogical interaction – educational computer games – which necessitates further research in this direction. The scientist's conclusions are fundamentally consistent with the results obtained in this research paper, adding significantly to the context of assessing the need for further research in the field of computer learning games.

At the same time, a group of scholars represented by N. M. Norwani et al. [34] in a joint research study aimed at investigating the teaching, achievement and development of high-order thinking skills among accounting students in secondary schools in Malaysia, emphasise that traditional teaching of accounting subjects is predominantly teacher-centred. According to the authors, increasing learner-centredness by engaging learners in play-based learning activities will enhance the quality of learning and develop the necessary competencies in students. The researchers' inputs do not fundamentally contradict the results of this research work.

A joint research study by a team of authors, represented by D. Hooshyar et al. [35], addresses a number of problematic aspects of game development with adaptive computational thinking. According to scientists' research, computational thinking is recognised as a quality skill set for learners in computer science and other academic disciplines. The authors came to the conclusion that most modern computer games do not take into account whether learners learn computer game programming skills or directly adapt to the needs of individual players. The researchers' conclusions agree in principle with the findings of this research in the context of assessing the need for a varied programming environment for each learner, depending on the task at hand and his or her current needs.

L. R. Larke [36], in a research paper on the role of the teacher in the implementation of a computer science curriculum in England, notes that the addition of computer technology to the curriculum of educational institutions in this country has been approved as a necessary modernisation of this curriculum in the context of the need to develop digital skills. At the same time, the author points to the fact that the field of implementing educational games in the context of educational process optimization shows that even quite simple educational games can be very motivating and can actually initiate the process of improving the quality of learning new topics. The researcher's conclusions require some clarification in the context of assessing the role of educational games, in relation to specific categories of students.

The research team of S. Grover et al. [11], in a collaborative research study, looked at combining non-programming activities, concluding that curricula in educational institutions should be structured so that students have every opportunity to succeed in learning computing. According to the authors, educational games in this context have a particularly important role because they are optimally integrated into the process of training students in the study of programming and computer science basics, representing an effective means of developing logical thinking and spatial imagination necessary for effective work with computer technology. The conclusions of the researchers do not contradict the results of this research work, complementing them in the context of evaluating the role of educational games in the learning process.

T. Dorgan [37], in a scientific study aimed at examining the specifics of the construction and practical use of video games within the modern education system, notes the existence of different levels of involvement in video games, which may be significant in terms of assessing the role of such models of learning in the educational process. According to the scholar, gender is not a determining factor in assessing the degree of involvement in video games, moreover, a number of games require high cognitive skills, which is the reason for the wide popularity of video games as one of the modern means to optimize the learning process. The scientist's conclusions seem very controversial in the context of their comparison with the results of this research work, since the issues of assessing involvement in learning group games according to gender are debatable.

Researchers L.A. Butabayeva and M.T. Imasheva [38] in their scientific work dedicated to the study of the role of folklore in the speech development of young pupils with intellectual disabilities note that nowadays the material of such sciences as linguistics, psycholinguistics and folklore studies gives an opportunity to actively correct various speech disorders, if lessons in this direction are started early. In this case, according to the authors, it is particularly important to organize this kind of classes based on the use of educational games, with the involvement of computer technology. This allows the students to focus their attention on specific legends, tales, proverbs presented in a game form, which will contribute to the development of their imaginative thinking. The results of the researchers do not fundamentally contradict the results obtained in this research work, significantly complementing, and extending them.

The topic of the development of children with disabilities and their subsequent social rehabilitation is developed by a team of authors represented by Zh. I. Namazbayeva et al. [39]. According to researchers, the percentage of children with various speech impairments increases every year, with international statistics suggesting that 17.5% of children under the age of seven have such problems. Organising play-based group

activities for these children at the stage of their specialised primary school education contributes to a systematic solution to this problem. Researchers believe that this requires the development of special computer programs for teaching spoken language, aimed at organizing effective interaction between the teacher and the children in the framework of game lessons, in order to repeatedly repeat the same word forms and their gradual assimilation. The results obtained by the researchers correspond in principle with the findings of this research work, complementing them in the context of highlighting the practical benefits of using educational games in work with children with disabilities.

For their part, the team of authors D. Bau et al. [40] conducted a collaborative research study on building blocks in instructional programming, in which they pointed out that block programming experiences can be useful in beginning to learn more traditional or complex text-based languages. The authors point out that the increasing ease of practical application of block programming has led to its widespread use in the context of introductory programming in different age groups, which is essential when applying programming methods in the development of educational games in the context of supplementary education in computer science. The results obtained by the researchers are fundamentally consistent with the findings of this research study, serving as a further development, in relation to the evaluation of the role of block programming in the construction of children's educational games.

According to a group of authors represented by G. Steiner-Khamsi et al. [41] who have investigated the key principles of understanding business interests in international large-scale student assessments, the quality of modern education can be significantly improved by improving teacher effectiveness and the competent implementation of private initiatives, one of which is the use of learning games in the classroom as a supplementary learning tool. In this context, according to the researchers, the competence of the implementation of educational games in the learning environment and the effectiveness of the control of this process by the teaching staff of the educational institution will be of particular importance. The conclusions of the research team are fully consistent with the results obtained in this research paper.

Thus, the discussion of the results obtained in this research work in the context of their comparison with the results of a number of other research studies on related topics demonstrates their basic overlap in terms of the essence of the issues raised. This demonstrates the scientific validity of the findings of this research and the acceptability of their subsequent application in practice.

Conclusions

In this research the actual problem of teaching programming to schoolchildren was considered. Nowadays, information technologies occupy an important place in human life, but the school education system does not manage to include new approaches, methods, and knowledge in the educational process. Changing additional education and introducing the subject of computer science to teach children programming is an important and challenging task.

In particular, the complexity of learning to program is due to the complexity of syntactic and logical code constructs, requiring learning to program using simpler examples, such as visual programming. The visualisation of programming instruction allows for practical experience that will allow the learner to develop and further develop skills for future specialisation. Visual programming tools (Scratch software) allow to form a varied programming environment for each student depending on tasks and needs, provide an opportunity to learn common approaches to software development in integrated visual environments, consider working with interfaces and program code, and all this can be combined with the use of educational games. Students develop educational projects to create game-based applications in the learning process.

The presented review of game-based learning determines the fundamental possibility of its application in the construction of the educational process in an educational institution. The educational theory underlying game-based learning, its characteristic techniques, and features, as well as advantages, disadvantages are aimed at finding practical opportunities for organizing the process of creating educational games in the conditions of additional education in computer science. Methodological recommendations for the development of a supplementary education course in computer science at school will contribute to the achievement of optimal results. In the course of the study the hypothesis was proved that learning presented in different game forms is essential in terms of developing competences necessary for students to successfully master computer technology. One possible tool that would allow all learners to integrate easily into the process is block-based visual programming tools.

It is also recommended to develop and implement block-level structure of programming content in visual media in the educational process of Kazakh National Pedagogical University named after Abay. The development of methodological recommendations for teachers of additional education on creating educational projects in an integrated visual programming environment Delphi, the use of teaching aids for teaching programming in this integrated visual environment seems to be effective.

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Conflict of Interest

None.

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Модель навчання учнів створенню навчальних ігор у додатковій освіті з інформатики

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Анотація

Актуальність. Актуальність заявленої теми даного дослідження визначається наявністю значних змін у сучасних освітніх процесах, які зумовили підвищення значущості питань цифрової грамотності та інформаційно-технологічної освіти учнів на всіх рівнях навчальних закладів.

Мета. Основною метою даного дослідження є вивчення ключових принципів моделі навчання учнів створенню навчальних ігор у системі додаткової освіти з інформатики на прикладі середовища програмування Scratch.

Методологія. Методологічний підхід у цьому дослідженні ґрунтується на поєднанні методу системного аналізу принципів використання навчальних комп'ютерних ігор у навчальному процесі та комплексному дослідженні впливу ігрових методів проведення занять на засвоєння учнями навчального матеріалу. Наукове дослідження проводилося на базі Казахського національного педагогічного університету імені Абая.

Результати. У даному науковому дослідженні були отримані результати, що свідчать про наявність у студентів принципових можливостей для підготовки індивідуальних моделей навчальних ігор, спрямованих на стимулювання їх активності в процесі навчання, підвищення їх мотивації та залучення в навчальний процес. При цьому навчальні ігри можуть бути використані для створення якісної моделі для окремого учня; фактично, такі ігри надають широкі можливості для взаємодії учня з комп'ютером, що може бути використано в подальшому для розробки ефективних моделей навчальних ігор при розробці додаткових методик навчання інформатики.

Висновки. Практичне значення отриманих у даному дослідженні результатів та сформульованих на їх основі висновків полягає у можливості їх застосування при створенні додаткових ігрових навчальних матеріалів, призначених для розвитку інформатичних компетентностей учнів, набутих під час навчання у навчальному закладі.

Ключові слова: ігрове навчання; інформатика; додаткова освіта; програмування; Scratch.