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Methods of Teaching Computer Science Based on Mobile Technologies

Author(s), O'RINOV NODIRBEK TOXIRJONOVICH,
QODIROV MUZAFFAR OLIMJON O'G'LI,
AND
NAZAROVA BARNO USARBAYOVNA

Abstract:

The article discusses methods of teaching computer science at school based on the use of mobile devices (smartphones, tablets and other portable computers) and cloud technologies that provide information exchange between students and teachers. Based on the didactic tasks that arise in the learning process, appropriate teaching methods are proposed, focused on the work of students with different types of information and the development of software products using mobile devices. Considering the subject specifics of the discipline "Informatics and ICT" at the school, offers teaching methods aimed at developing algorithmic thinking and developing basic skills in developing software products using mobile devices. In terms of learning and developing skills in working with software products, it is suggested to use a mobile device as a second screen for easy access to electronic instructions, for example, in the form of a screencast. In the considered teaching methods, such components as the purpose and conditions of using the method, the activity of the teacher and student, the method of controlling the result and the criterion for achieving it are detailed. To organize joint activities of students both in the classroom and in extracurricular work, it is proposed to use cloud technologies, which in addition allow you to use cloud storage to place electronic course materials and support it. Based on the variety of teaching methods and didactic tasks, it is concluded that it is advisable to systematize them, develop principles for building a system of teaching methods and test them

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in the real educational process.

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About Author

Author(s): O'RINOV NODIRBEK TOXIRJONOVICH,
Teacher, Department of Information Technology, Andijan State University,
Uzbekistan.
E-mail: nodirbekurinov1@gmail.com

QODIROV MUZAFFAR OLIMJON O'G'LI
2 – year magister of Andijan State University in Information Technology
Education, Uzbekistan.
muzaffar_qodirov93@mail.ru

NAZAROVA BARNO USARBAYOVNA
2 – year magister of Andijan State University in Information Technology
Education, Uzbekistan.

Problem statement

Mobile devices and cloud technologies are permeating all areas of human activity. With the help of personal mobile devices, the speed of access to information is significantly increased due to the presence of an Internet connection module, and their functionality sometimes exceeds the capabilities of desktop computers due to built-in photo and video cameras, a microphone, a tilt sensor, geolocation tools, and others. In society, the priority is changing from "it is important to know" to "it is important to have access to information". However, at school it is still customary to "teach to remember", and not to work with information. At the same time, mobile devices are the most convenient means of accessing information due to their small size and high functionality. Thus, the issue of teaching computer science becomes relevant, taking into account the trends in the development of information and communication technologies, and in particular, mobile and cloud ones.

In our previous work [12], based on foreign and domestic experience, we analyzed the feasibility of using mobile technologies in the field of computer science, including the use of e-mail, mobile survey and control systems, microblogging, augmented reality, and other technologies and services. Based on the features and advantages of mobile devices over stationary computers, other options for their use in teaching computer science were proposed:

- using a mobile device as a second screen;
- mobile device as a tool for performing practical work;
- mobile device as a tool for reminding and repeating educational material.

Since theoretical approaches to the use of mobile devices in computer science lessons are currently poorly developed, and their importance and role in the life of modern people is increasing, the issue of identifying and developing teaching methods based on mobile technologies becomes relevant.

Didactic tasks solved using mobile technologies

Agreeing with the opinion of B. E. Starichenko that the use of any information educational technologies, including mobile ones, is determined by their didactic expediency [16], we will consider the possible tasks and directions of using mobile devices in the educational process.

The task of expanding the presentation of educational material and increasing visibility

One of the most modern and promising forms of presentation of educational material is augmented reality. Considering the use of augmented reality technology as a learning tool, researchers note that it "gives students the opportunity to see the world around them in a new way and deal with real problems in the context with which they are already connected" [28, p. 86]. Despite the development of technologies and technical capabilities of smartphones, the use of augmented reality applications in education is difficult for several reasons [21]:

- ✓ cognitive overload (according to a study [29], students are often overwhelmed by the complexity of learning activities);
- ✓ the school education system is poorly compatible with augmented reality technology; the system of evaluating достиженийstudents ' achievements is complex;

✓ the effectiveness of using augmented reality applications strongly depends on the teacher's skills [30];

✓ technical problems [22].

Thus, for the effective use of augmented reality tools, it is necessary to develop a method of presenting materials that does not require significant labor costs from the teacher, is sufficiently simple and accessible on any modern mobile devices.

One of the features of mobile devices is their ability to reproduce various content (photos, animations, video and audio files, text, 3D images, etc.), which allows you to diversify the ways of presenting the course material.

Thus, mobile devices open up new opportunities for teachers to present educational content, place it, and distribute it.

The task of organizing a game-based form of training

Game technologies and the "gamification" of the learning process find new ways of development through the use of mobile devices as a technical platform. Scenarios of using such a learning format are characterized both by the teacher's involvement directly in the game process [24] and by the teacher's and students ' autonomy [26]. The inclusion of a game form of learning using mobile devices can contribute to achieving higher educational results [20] by increasing motivation [19].

A study of leisure needs and preferences of teenagers has shown that quest is one of the most popular genres of computer and Internet games [6]. Quest – from the English quest-search) is a genre of games that require the player to solve mental tasks in order to advance along the route. According to the degree of reality, quests are divided into real and virtual ones. Quest participants note that this form of gaming activity contributes to the development of logic, attention, and intelligence as an attractive aspect [18].

To increase students ' learning motivation and organize group research activities, web quests are often used, defining them as:

✓ a needs-oriented activity where some or all of the information that students interact with comes from Internet resources [31];

✓ a problem task with elements of a role-playing game that uses Internet information resources to complete it [2, p. 262];

✓ A web project, while some or all of the information that the student works with can be found on various websites [3].

Researchers note that the key element of the quest is a list of links to resources that are necessary for completing the task and are selected by the teacher in advance [17, p. 90]. According to the duration of work with the quest, short-term and long-term tasks are distinguished, and regardless of the type of quest, it has a certain structure [25, p. 110]:

• Introduction. At this stage, students need to understand what they will learn and do during the quest. The teacher suggests a scenario, story, or task on a specific topic in a way that will interest students.

• Task. This is the main stage of any quest. The teacher offers a pre-designed task for working on the topic, including questions and sub-questions. The task should be realistic, feasible, and contribute to the disclosure of the main educational topic. Sub-tasks should be simpler than the main task and relate to its individual aspects.

- Process. Students receive instructions for completing the task and complete it according to the proposed stages.
- Resources. Students receive addresses of websites on the Internet that are recommended by the teacher for completing tasks on the topic.
- Performance evaluation. At this stage, students have the opportunity to evaluate their work results and compare them with the results of their classmates ' work. The teacher makes comments about the students ' work.
- Conclusion. This stage is necessary for students to compare the result obtained with the goal set at the beginning of the work. Also, at this stage, it is necessary for students to realize the possibility of using the acquired knowledge and skills in other areas of activity [11, p. 149].

The proposed definitions and structure of a web quest explain how web technologies are used, but the concept of a quest as a game genre remains undisclosed.

First, the game activity, as a rule, involves the presence of an interesting, unusual, original idea as a tie for the main plot. However, in the structure of the educational web quest discussed above, the level of motivation at the introduction stage depends on the teacher's skill, since his role is to offer at ask or task to students. Secondly, the quest as a game genre assumes a multi-factor development of events, while a linear (step-by-step) algorithm for achieving goals is proposed. Thirdo, games have a player-a reward system, and comparing student performance and teacher evaluation is not such a tool. Based on this, the proposed definitions of a web quest reveal and clarify the concept of a "web project" performed by students jointly or individually on educational topics through Internet technologies and web resources.

Thus, to implement the gameformof learning, it is necessary to use services that will allow simulating the game situation regardless of the subject component, which will allow the teacher to focus on the content of the game, and not on the plot.

The task of improving the visibility and interactivity of instructions on working with software products

One of the substantive branches of the Computer Science and ICT course at the school is the development of skills in working with software products. Using mobile devices in this case allows not only to reduce the emotional stress that occurs when switching between the instruction windows and the computer application being studied, but also to expand the use of various content (for example, instead of text instructions, use video lessons). For example, video and screencast technologies allow us to diversify the ways of presenting educational material and organize the process of mastering software tools and applications in a new form, offering a number of didactic advantages [14].

Thus, the task arises of developing training content adapted to mobile devices and choosing the appropriate training method.

Task of organizing a survey and testing system

Foreign studies describing the experience of using mobile survey systems in the classroom call for using the capabilities of students ' smartphones instead of using restrictive measures [23]. The advantages of using mobile survey systems include the following [27]:

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✓ increased interactivity in the classroom (students become more attentive to the learning process, their involvement increases, interaction and feedback are organized);

✓ using such a system in the classroom is an unusual and interesting experience for students;

✓ ability to conduct anonymous voting;

✓ easy to use;

✓ using the mobile survey system introduces a modern technical component to the learning process;

✓ the teacher gets the opportunity to timely record the level of understanding of the educational material by students, which allows you to adjust the course of the lesson.

During the testing of mobile survey systems, researchers have identified a number of disadvantages of their use in training, which are related to the fact that [27]:

✓ a technical failure may occur;

✓ there are no open questions (there are always possible answers).);

✓ some students don't take the survey seriously;

✓ using a mobile phone may distract the student;

✓ voting using mobile devices takes up time in class.

Another approach to organizing a mobile survey is to use the ability of a teacher's smartphone to read individual student cards. In this case, the presence of smartphones and the Internet is not a prerequisite for students. The teacher can create their own map sand assign them to their classes. The experience of practical use of such a survey system has shown that this approach has a number of advantages in conditions of insufficient technical equipment of the school [8].

Thus, to successfully organize a survey or test, you need to choose the most convenient and effective service, prepare appropriate content, and organize student activities.

The task of teaching the basics of algorithmization and programming

A mobile device is essentially a portable computer that sometimes exceeds the capabilities of school computers. Therefore, in computer science classes, mobile devices can be used as a means to perform practical work (for example, when studying topics related to the Internet, information transfer and search technologies).

The researchers note that " today the computer science teacher has unique opportunities to form the cognitive interest of schoolchildren in the process of learning programming, primarily due to the wide range of software environments used. So, for example, in computer science lessons, when studying programming, teachers actively use visual programming environments (Scratch, Kodu, Alice, etc.), focused on the development of "desktop" applications, which, of course, arouses great interest among schoolchildren, but does not satisfy it completely. This can be explained by the fact that in addition to computers, students are increasingly using mobile devices" [7, p. 2].In addition, it seems appropriate to use such methodological approaches that would provide a logical connection and continuity of course topics related to the development of software products and the basics of algorithmization [15].

Thus, to increase the cognitive interest of schoolchildren, it is necessary to use a method of teaching programming, in which mobile devices can be used as target platforms (along with personal computers).

The task of developing skills in working with software tools

One of the most important components of the computer science course at school is the development of skills in working with various software products and information systems. In the school computer science course, traditionally computer laboratory workshops occupy a significant share compared to working in mobile applications, despite the widespread use of mobile devices.

Thus, it is advisable to build a system of training methods aimed at developing skills in working with software based on mobile devices.

Task of organizing project activities

Mobile devices are, on the one hand, the subjects of study of the discipline "Informatics and ICT", and on the other hand, they act as target platforms when working on research projects and students. The active spread of mobile technologies and devices in modern society reflects the urgency of developing software products for them. And the presence of their own smartphones among students helps to increase internal interest and personal motivation in developing new programs for their device.

Thus, project activity within the framework of developing applications for mobile platforms becomes a promising field of work.

The task of organizing independent and group work of students

The use of mobile devices in the framework of independent work of students provides ample opportunities to work with various types of information. Since the smartphone in most cases includes a geolocation module, a photo and video camera, a microphone and audio speakers, and also has built-in tools for working with various types of information, students have wide opportunities to use the mobile device as a tool when performing independent work (both classroom and extracurricular). Thanks to cloud technologies, in the course of solving educational tasks, the smartphone can also act as a means of communication between both a group of students and a teacher.

In the conditions of insufficient equipment of schools or due to the lack of personal computers for students, a mobile device offers the same opportunities, since it is essentially a miniature computer. Thus, the implementation of practical and independent work in the discipline "Informatics and ICT" can often be organized both with the use of a stationary personal computer and with the help of mobile devices.

Thus, it is necessary to use the communication capabilities of mobile devices when implementing training methods aimed at independent work of students. These didactic tasks can be solved with the help of appropriate teaching methods, which will be described in more detail.

Methods of teaching informatics based on mobile technologies

Learning as a process of interaction between the teacher and students aims to transfer the totality of accumulated knowledge, experience and methods of activity included in the content of education, as well as the development of individuality and socialization of the individual. Based on the goals and objectives of training, as well as the educational

opportunities of students to learn knowledge, researchers have proposed various options for defining the concept of "teaching method". Generalization of the definitions given in the works of Yu. K. Babansky [1], I. Ya. Lerner [9], M. I. Makhmutov [10,p. 62], M. N. Skatkina [4, p. 151], allows us to distinguish the following component composition of the training method:

- ✓ the purpose of the method application;
- ✓ terms of use;
- ✓ teacher activity;
- ✓ student activity;
- ✓ the method of controlling the result and the criterion for achieving it.

Modern information technologies, including mobile and cloud, provide new opportunities for organizing interaction between participants in the learning process. Thus, mobile technologies have an impact on teaching methods, as they provide new means for organizing the activities of both the teacher and the student, changing the mechanism of the student's movement towards the goal. The technological basis has an impact on the implementation of the training method, respectively, to describe the training method means to describe the following components:

- ✓ didactic goal;
- ✓ technological basis;
- ✓ the procedure of the teacher's actions;
- ✓ the procedure of the student's actions;
- ✓ the criterion for achieving the goal.

Most of the methods of teaching based on mobile technologies discussed below can be used not only in computer science lessons. However, the subject specifics of the discipline "Computer Science and ICT" in the school course sets the teacher a number of didactic tasks that are typical for her to solve. Consider the methods of teaching based on mobile technologies in their connection with the solved didactic tasks (Table 1).

Visual programming method

Visual programming tools allow you to develop the skill of algorithmic thinking of schoolchildren based on knowledge of elementary basics. The use of a mobile platform in software development is a motivating factor for students, as it reflects the trend of IT development [7].

Purpose of applying the method:

development of algorithmic thinking and programming skills. Increase the level of motivation to learn the basics of programming.

Table 1
Linking mobile-based learning methods with didactic tasks

Didactic task	Training method
The task of expanding the forms of presentation of educational materialand increasing visibility	• Educational QR-quest method • Interactive video method
The task of organizing a game form of training	• Mobile Quiz Method • Educational QR-quest method • Web Quest method
The task of increasing the visibilityand interactivity of instructions for working with software products	• Method of podcasts, screencasts • Interactive video method
The task of organizing системы a surveyand testing system	• Mobile survey and voting methods • Mobile Quiz Method
The task of teaching the basics of algorithmization and programming	• Visual programming method
The task of developing skills in workingwith software tools	• Method of podcasts, screencasts • Interactive video method
The task of organizing project activities	• Visual programming method • Project Method • Cloud Research method
The task of organizing independentwork of students	• Podcast Method
The task of organizing joint activities	• Cloud Research Method
The task of mastering mobile technologies	• Mobile Search method • Interactive video method • Podcast method, screencasts

Conditions for using the method: availability of computer devices (mobile or stationary), Internet access.
Teacher's activity:
  ✓ preparation of training tasks (or their transformation, taking into account the features of visual programming for mobile devices);
  ✓ assistance and advice to students in the course of independent work;
  ✓ checking the completion of tasks.
Student activity:
performing practical work in a visual programming environment where the target platform is a mobile device.

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With the aim of monitoring the result and criteria for achieving it:
- ✓ performing independent and creative tasks;
- ✓ the use of acquired skills in the design and research activities of students.

Mobile survey and voting methods

Mobile survey services allow you to conduct testing or formative assessment and allow you to get data from the entire class, rather than individual students. Instant feedback allows you to track each student's progress or difficulties in learning the material in real time.

Purpose of applying the method:
- ✓ classroom and extracurricular knowledge monitoring. Create a discussion based on survey results.

Conditions for using the method:
- ✓ mobile survey software on students ' devices, or
- ✓ access to cloud-based survey forms, or
- ✓ individual answer cards.

Teacher's activity:
- ✓ preparing a database of questions;
- ✓ planning the issue sequence of questions;
- ✓ monitoring the survey progress.

Student activity:
- ✓ forming your own answer to the questions posed based on the material studied and your own judgments.

Method for monitoring the result and criteria for achieving it:
- ✓ involving students in the voting process;
- ✓ ϕreal-time display of students ' training level;
- ✓ ability to instantly discuss survey results.

Mobile search method

Finding and working with various types of information is one of the most important skills of a modern specialist of any profile. Mobile devices with access to the World Wide Web offer additional information search capabilities due to the fact that in addition to a text query, a voice and graphic search query can be used. The content of the subject "Informatics and ICT" is aimed, in particular, at developing skills in working with modern information technologies and software products. Therefore, it is preferable to encourage the use of mobile devices for educational purposes, rather than prohibit them.

Purpose of applying the method:
- ✓ mastering working with information and communication technologies. Assimilation of new information.

Conditions for using the method:
- ✓ availability of access to Internet resources and search services.

Teacher's activity:
- ✓ creating problem situations that require finding additional information to solve them.

Student activity:
- ✓ choosing the best search methods and services;
- ✓ search for a solution to a problem or question.

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Method for monitoring the result and criteria for achieving it:
- ✓ students ' development of mobile search technology.

Project method

Mobile devices and cloud technologies allow you to organize project activities at a new level, as they provide both new tools that are always at hand, and a convenient organizational form. For example, most smartphones have built-in tools such as compass, navigator, map, camera, flashlight, and others. In turn, the cloud-based organization of data storage allows for instant information exchange between a group of students and a teacher. In addition, the development of mobile applications is of great interest to students, as their distribution is широкомасштабныйwidespread.

Purpose of applying the method:
- ✓ вperforming individual and group design and research activities.

Conditions for using the method:
- ✓ availability of mobile devices as target platforms;
- ✓ availability of mechanisms for remote interaction between students and teachers.

Teacher's activity:
- ✓ oporganization of students' design and research activities;
- ✓ providing assistance to students on the way to achieving the set goals of project work.

Student activity:
- ✓ pesolving project and research tasks (both individually and as part of group work).

Method for monitoring the result and criteria for achieving it:
- ✓ participation of students in the development of research projects related to mobile technologies.

Podcast Method

Video and screencast methods allow students, on the one hand, to get acquainted with software products at an individual pace, stopping and returning to problem areas, and on the other hand, to create their own reports in the form of podcasts, showing creative abilities. The use of podcasts brings diversity to the learning process, thereby increasing the motivation of students to learn the content of the course.

Purpose of applying the method:
- ✓ development of skills in working with software products. Working with the software.

Conditions for using the method:
- ✓ availability of mobile devices with video recording function;
- ✓ students have basic video capture and screen casting skills;
- ✓ a cloud-based environment for publishing videos.

Teacher's activity:
- ✓ preparing tasks for registration as podcasts;
- ✓ view completed work and adjust the student's actions.

Student activity:
- ✓ complete tasks and prepare a report in the form of a video or screencast.

The method of monitoring the result and the criterion for achieving it:
- ✓ students' use of podcasts in the context of studying software products;

✓ use of cloud-based screencasts and video clips as forms of report on homework related to the study of software products.

Mobile quiz method

The use of mobile technologies for organizing game-based learning makes it possible to organize both group and individual work in the form of interactive quizzes. This approach contributes to the development of students ' skills to control their activities in the process of achieving results. Setting a time limit develops a regulatory skill as planning the rhythm of your work.

Purpose of applying the method:
✓ classroom control;
✓ checking your homework assignments;
✓ checking the assimilation of new material.

Conditions for using the method:
✓ availability of mobile devices for students;
✓ availability of Internet access.

Teacher's activity:
✓ preparing quizzes;
✓ control and organization of students' activities;
✓ discussion and correction of students' actions.

Student activity:
✓ participation in the quiz;
✓ discussion of the results.

With the aim of monitoring the result and criteria for achieving it:
✓ engaging students in the game process.

Cloud research method

The specific feature of this method is that students jointly or individually investigate any question of the educational topic or problem in order to prepare a report and make a speech to the class. Mobile and cloud technologies allow you to create joint electronic documents and presentations that can be edited simultaneously by several students and teachers. When organizing group work within a team, each student explores their own part, collecting the necessary material, placing it in a cloud document, and then based on the collected parts, a general report of the group is formed.

Thanks to time-and place-independent access to the developed cloud materials, the cloud research method is applicable both in classroom work and in extracurricular work.

Purpose of applying the method:
✓ organization of interaction of students on the way to solving assigned educational tasks.

Conditions for using the method:
✓ availability of cloud materials available to students;
✓ in a computing device that has access to the Internet.

Teacher's activity:
✓ preparing cloud-based documents and distributing the link to students;
✓ preparing training tasks for execution in the cloud environment.

Student activity:
- ✓ completing a practical task in a cloud environment.

The method of monitoring the result and the criterion for achieving it:
- ✓ active use of cloud-based sharing resources in the process of solving educational tasks.

Educational QR Quest method

Since QR-quests allow you to store small texts and links, it is possible to use them in a learning environment with or without Internet access. Creating a QR-quest increases the motivation of students for independent cognitive activity due to the game element.

Purpose of applying the method:
- ✓ вивеintroduction of additional methodological educational resources to the educational process;
- ✓ creating an attractive organizational form for students to work on educational material.

Conditions for using the method:
- ✓ students have mobile devices with software that allows them to decode QR codes.

Teacher's activity:
- ✓ preparation of methodological developments with elements of QR codes.

Student activity:
- ✓ scanning QR codes, decoding them.

The method of monitoring the result and the criterion for achieving it:
- ✓ active use of QR-coding tools by students in the educational process.

Interactive video method

Modern mobile devices allow you to play video content. However, the value of any training video is reduced due to the lack of an interactive element that could give feedback and establish how much a particular fragment is learned by listeners. Thanks to the services for adding surveys to videos, teachers can create interactive video lessons by attaching surveys, tests, open-ended questions, and links to other resources.

Purpose of applying the method:
- ✓ introduction of additional methodological educational resources into the educational process;
- ✓ creating an attractive organizational form for students to work on educational material.

Conditions for using the method:
- ✓ students have mobile devices with Internet access.

Teacher's activity:
- ✓ preparation of video materials and questions.

Student activity:
- ✓ study of video content;
- ✓ answers to questions during viewing.

Method for monitoring the result and criteria for achieving it:
- ✓ students ' use of interactive video lessons;
- ✓ monitoring the survey results.

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Web Quest method

The game form of conducting classes increases the motivation and activity of students, and an electronic quest, available via the Internet, allows you to organize both extracurricular and extracurricular work of students. Based on the didactic advantages of using quests in teaching [32] and the disadvantages of existing approaches to organizing web quests, we developed an electronic resource for creating interactive quests learnis.ru [13]. It is based on a subspecies of the quest genre – "exit the room", in which the player is faced with the task of getting out of a virtual locked room, using hints and objects in the room. Hints can be either explicit, or in the form of riddles or educational tasks, the solution of which will be a hint for the long-range implementation of actions.

The distinctive features of the Learnis service [13] are:
- ✓ there is no game situation (you need to get out of the room);
- ✓ non-linearity of passing (the trainee chooses in what order to solve game / training tasks);
- ✓ ability to add data from any subject area to the quest;
- ✓ at the end of the quest, the student receives a reward determined by the teacher;
- ✓ quest compatibility with mobile devices;
- ✓ ability to assign a quest as a homework assignment.

Web quests can be used both for individual, independent work, and in a group form. In addition, if you have an interactive whiteboard or a projector with a screen, the quest can be completed as part of a teacher-student collaboration. This format of the lesson encourages students and allows them to consolidate the learning material in an interesting way [5].

Purpose of applying the method:
- ✓ create an attractive, playful form of conducting classes to repeat and learn new material.

Conditions for using the method:
- ✓ whether students have devices with Internet access (when working independently with the web quest).);
- ✓ налthe teacher has a computer with access to the Internet and a projector with a screen (for front-end work in the classroom).

Teacher's activity:
- ✓ preparing a web quest for students;
- ✓ connecting students to the quest.

Student activity:
- ✓ completing subject tasks while completing the quest game.

The method of monitoring the result and the criterion for achieving it:
- ✓ participation of students in the web quest, discussion of the stages of its completion;
- ✓ the emergence of situations of discussion and mutual assistance between players.

Conclusion

TThus, modern information and communication technologies, the widespread use of mobile devices and the Internet expand the available teaching methods, changing their form and offering new ones. The variety of methods and didactic tasks that can be solved allows us to build the learning processing the most effective way, relying on organizational and

technological conditions and the content of the subject "Informatics and ICT" in the school course.

To build a system of methods for teaching computer science based on mobile technologies, on the one hand, it is necessary to systematize them, highlight the features and principles of building the system, determine the place of each method in terms of the thematic content of the course; on the other hand, to test the system in the real educational process. These parts of the study are currently being implemented; their results will be published.

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