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INFORMATION TECHNOLOGY OF DYNAMIC FORMATION OF CONTENT DEPENDING ON THE CHARACTERISTICS OF THE RECEIVING -TRANSMITTING SYSTEM

Annotation. This paper presents an information technology for dynamic formation of content in conditions of limited resources. Due to the developed information technology, when connected to the site, the user will receive information in the form that his device can play. Information technology of dynamic formation of content consists of four stages: course formation, test formation, determining of the characteristics and display of information. The stage of course formation is based on a model of a system for receiving and transmitting information, namely, on the user's presentation and information resource. The presentation of the user includes the model of the receiving part of the system for receiving and transmitting information and the type of user in terms of access rights. The presentation of an information resource includes a basic content model and many registered users. In turn, the basic content model includes content that consists of multiple sections, and each section can be divided into multiple section elements. The test formation stage is based on the model of the system for receiving and transmitting information and contains an assessment of the representativeness of the test to ensure its quality, which is based on an analysis of the proportion of the number of questions covering different sections and educational objectives of the course. The steps of characterization and display of information are based on the method of dynamic formation of content. The main modules and users of information technology of dynamic formation of content are implemented using the information system "system of the dynamic determination of content". Approbation of information technology was performed at the Odessa Polytechnic University in disciplines that use elements of distance learning to ensure that all information on the course is viewed, regardless of the communication channel and students' devices. To assess the quality of the developed information technology, an experiment was conducted with the participation of students. As a result of the experiment, it was proved that the quality of the process of receiving and transmitting information increased by 1.55 times due to the use of the developed information technology.

Keywords: distance learning; mobile learning; content; content formation; receive data; transmit data; dynamic content formation; limited resources

Introduction. Formulation of the Problem

Not so long ago, during the reception and transmission of large amounts of information on the Internet, a large number of problems arose, most often there were delays in receiving and transmitting information and the quality of reproduction of all types of content suffered: text, images, video, etc. But thanks to the rapidly growing characteristics of the systems of reception and transmission, storage, processing and display of information, work on the Internet has become a daily task.

Despite this, today there is still the problem of playing content: working with multimedia, watching videos, images, etc. Most often it occurs in users who use devices with low performance or due to poor communication channel [1-4], because the quality of the process of receiving and transmitting information (RTI) significantly depends on the characteristics of software and hardware. Thus, users do not receive the information of interest to them [1-3] and leave the resource that was viewed. As a result, organizations that provide such content lose poten-

tial customers because users have not opportunity to view it [3-4].

The solution of the tasks of the RTI is significantly complicated by the heterogeneity of the information environments used in the systems for receiving and transmitting information (SRTI). At the same time, very different hardware is used, the characteristics of which (processor, memory, network equipment) lie in a wide range. Software (operating systems, browsers, information compression tools, network protocols of different levels) is also very different. All of this can vary in different sessions, even for one user, so there is a problem of compatibility of all components of the SRTI and this, in turn, affects the quality of the RTI process.

New information compression methods [5], new PPI protocols [6-7], intelligent tools for analyzing and dynamically adjusting RTI processes [8-10] are currently used to adapt content to the characteristics of software and hardware. However, organizations that have a small budget, as well as users who have low characteristics of their devices cannot use the proposed options. Most often, such organizations

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include those that provide distance learning services, regardless of which intermediary they use [11].

Development of information technology for dynamic formation of content in conditions of limited resources provides the user with such content, which he can view using his software and hardware, and therefore is an urgent task.

The purpose of this work is to improve the quality of the process of receiving and transmitting information in the context of limited resources through the development of information technology for dynamic content generation.

The quality of the process of receiving and transmitting information depends on the reproduction of all types of content. It is proposed to evaluate the quality of the RTI process as a percentage of users who do not leave the site due to the delay of the RTI and reproduction of information.

According to the goal it is necessary to solve the following tasks:

- highlight the main stages of the information technology of dynamic formation of content, indicate their connection with the models and methods on the basis of which the information technology was developed;
- describe the main stages of the information technology of dynamic formation of content;
- specify an information system that was developed to implement information technology for dynamic formation of content;
- perform testing of developed information technology.

The presented method takes into account previous developments. In [2-3; 12-15] goals of the educational process were introduced and the types of content were described: content types are used for the course formation and test stages, the goal - for the test formation stage. B [3] proposed the formation of a learning style based on the behavior of the student, to determine the adaptability of the content, this is taken into account for the information display stage. The SRTI model, on which the information technology of dynamic formation of content is built, is an evolution of the model [15]. A method for adapting content according to the amount of information transmitted, which is part of the step of determining characteristics, is presented in [16]

Information technology of dynamic formation of content

The information technology of dynamic formation of content development of a distance course is based on the model of the receiving part of the system for receiving and transmitting information, the basic model of content and the SRTI model, the method of dynamic content formation [4-6; 17].

The main stages of the information technology of dynamic formation of content are: course formation, test formation, determining of the characteristics and display of information.

In Fig. 1 shows the main stages and modules of the system, their relationship with the models and method used, and the main users in the information technology of dynamic formation of content.

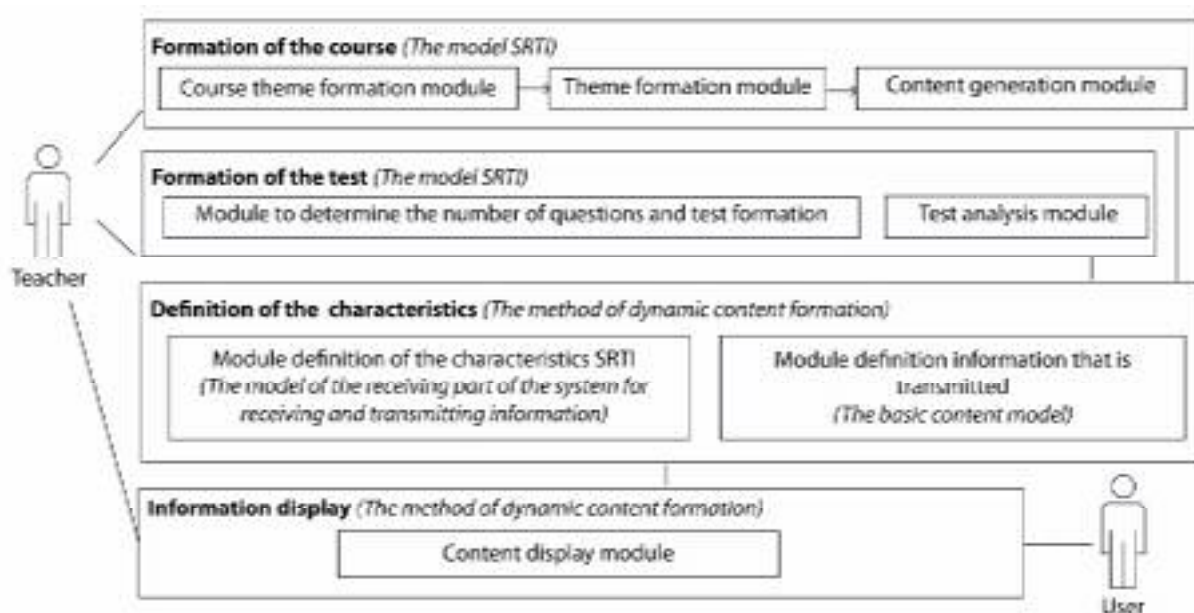


Fig. 1. The main stages of the information technology of dynamic content formation

The stages of the course formation and the test formation are based on the model of SRTI. The course formation stage includes a course generation module, a topic formation module, and a content generation module. The test formation stage contains a module for determining the number of questions and test formation and a test analysis module.

The steps of determining of the characteristics and display of information are based on the method of dynamic formation of content.

The display of information stage includes a content display module.

The stage of determining of the characteristics consists of a module determining the characteristics of the receiving part of the system, which is based on the model of the host of the SRTI and the module determining the information that is transmitted, the module is based on the basic content model.

The stages of the developed information technology consider in more detail.

Formation of content in the SRTI model can be divided into two parts:

- formation of a distance course, namely: lectures, laboratory and practical work;
- formation of the test, namely: test tasks to verify that students are learning information from sections of a distance course and the entire course as a whole.

The course formation stage

The stage of formation of the course is based on the SRTI model [4-6; 17], which includes the model of the receiving part of the system for receiving and transmitting information, the basic model of the content and the presentation of the information resource and the user.

Presentation of a user

User k , from the point of view of the technical capabilities of the means of obtaining content provided by an information resource, can be represented as follows:

$$k = \langle RD, tk \rangle,$$

where:

RD – the model of the receiving part of the SRTI;

tk – user type in terms of access rights.

Depending on the characteristics of the software and hardware, the information provided to the user may be displayed differently. In this paper, it was proposed to consider three types of devices at the first level of analysis of the receiving part of SRTI: personal computers/laptops, tablets, smartphones. In addition, the quality of the content that the user can view, taking into account the software

and hardware, depends on: the speed of the RTI, the operating system of the receiving side, the software for displaying the content (browser), the screen resolution.

Based on this, was built the model of the receiving part of the system of transmission and reception of information [17]:

$$RD = \langle tc, tg, os, srd, p, ms, b, ssb, v_{pp} \rangle$$

where:

tc – the type of connection available to the user;

tg – the type of device with which the user gets access to the information;

os – the user's operating system;

srd – the resolution of the user's device screen;

p – the user's device processor;

ms – user device memory;

b – browser;

ssb – browser window size;

v_{pp} – RTI speed.

Presentation of an information resource

The developed system is designed for a large number of users and is intended for use on the Internet. Depending on the hardware characteristics of devices from which the administrator will provide data, the transfer of information can be performed in four ways (Fig. 2).

The presented technology should implement a mechanism for quality content display on all types of user devices, regardless of the data transfer rate and user device characteristics in real time. In these conditions to ensure the processing of requests and the provision of content to the user, the use of client-server technology is reasonably considered to be the best option for an architectural solution.

The information resource P , in terms of elements that can be stored and transmitted to the user, can be represented as follows:

$$P = \langle I, K \rangle,$$

where:

I – the basic content model;

K – many registered users, $k \in K$ – user.

The basic content model [28] is represented as:

$$I = \langle tp, d, C \rangle,$$

where:

tp – the type of content that will be used, depending on the user's characteristics;

d – section availability to a specific user;

C – content.

The availability of a partition to a specific user d is determined depending on the type of user in terms of access rights tk , which is determined in the user model k .

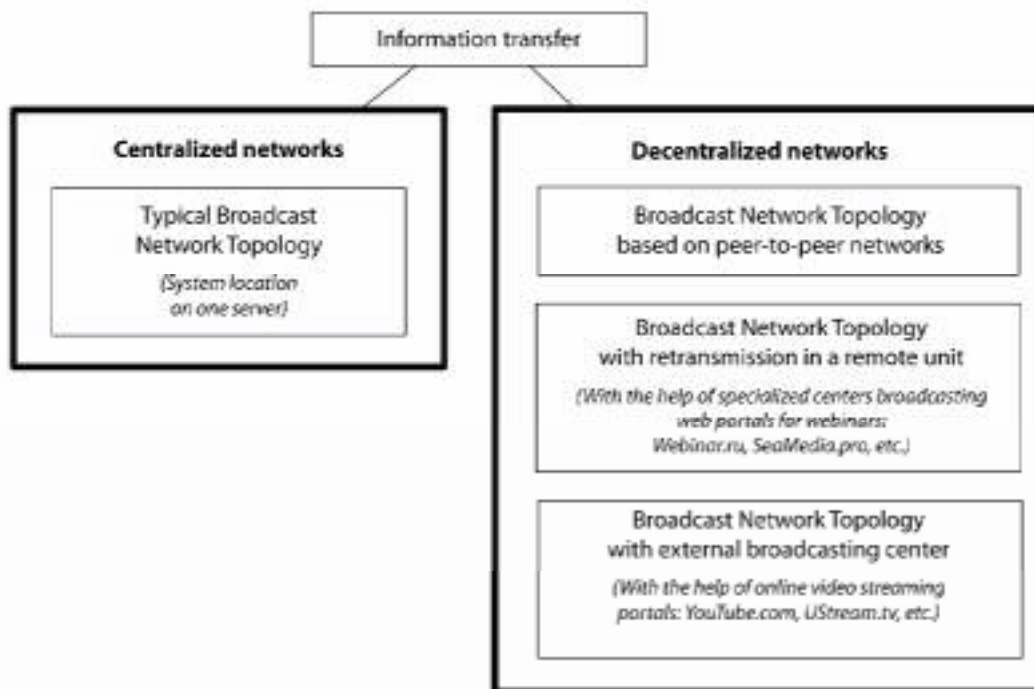


Fig. 2. Methods of information transmission

Content C consists of many sections of the site, each of which can have a number of elements:

$$C = \bigcup_{i=1}^n R_i, \text{ where } R_i = \bigcup_{j=1}^m r_{ij},$$

where:

R – many sections of the site that provides information resource;

$r \in R$ – an element of the section R ;

i – the index that indicates the minimum number of sections;

n – the index that indicates the maximum number of partitions;

j – the index that indicates the minimum number of elements in a particular section;

m – the index that indicates the maximum number of elements in a particular section.

The element of the section r in the general case can be represented as follows:

$$r = \langle tct, v_r, pr, sct, ct \rangle,$$

where:

$tct \in T$ – the content type of the item;

T – type of content (video, graphics, text, etc.);

v_r – the recommended RTI speed;

pr – the priority of using this element with other elements with an equal size of sct ;

sct – the size of the content element of the transmitted information in bytes;

ct – the content part of the element.

Based on the basic content model, we will present its developed version for a training course that is taught using IT, where the section element appears as follows:

$$r_r = \langle idct, di, tm, iz, tct, v_r, pr, sct, ct \rangle,$$

where:

$idct$ – course content item identifier (CCI);

di – the course to which the CCI belongs;

tm – topic to which the CCI belongs;

iz – mandatory presentation is equal to 1 if the CCI element is mandatory for viewing and 0 otherwise.

The test formation stage

The test formation stage in addition to presenting the test to the user in the form of certain content includes analyzing the test, determining the number of questions and the formation of the test. Without this stage, the information system for a distance course would not be complete as testing provides an objective assessment of the level of students' knowledge.

However, at the same time, the developed tests may contain tasks that do not cover the material of the discipline as a whole, and in this case the testing

cannot correctly determine the degree and quality of the material acquired by students.

Examination of test tasks is a prerequisite for creating tests, regardless of the scope of their application, because one of the drawbacks of modern informational learning systems is that test questions are not controlled by the system from the point of view of representativeness. Because of this, the test is subjective and weakly formalized. Therefore, the SRTI model, when forming tests, uses a method for assessing and increasing the representativeness of a test to ensure its quality, which is based on an analysis of the proportion of the number of questions covering different sections and training objectives of the course.

To determine the representativeness, a measure of compliance of the calculated characteristics of the test and the number of questions in the analyzed test are introduced, which is calculated by the formula:

$$M = \frac{\sqrt{\sum_{i=1}^m (n_i - n_{i\text{век}})^2}}{m},$$

where: M – a measure of compliance with the calculated characteristics of the test and the number of questions in the analyzed test;

n_i – the number of questions that need to be included in the test on the i -th theme;

$n_{i\text{век}}$ – the number of questions that were included in the test from the i -th theme before the calculation;

m – the number of themes.

The representativeness of the test is achieved when the value of the measure of conformity is equal a zero. The measure of compliance is zero provided that the number of questions included in the i -th theme of the training course coincides with

the number of questions that need to be included in the i -th theme. The higher the measure of conformity, the worse the representativeness of the test.

This stage allows teachers to analyze the representativeness of the test being studied, a fragment of a single course or comprehensive testing [18-19]. When using this step, it was practically found that the time spent working on calculating characteristics test was reduced twice.

Steps of determining characteristics and display of information

The determining characteristics and display of information is performed using the method of dynamic formation of content, which is based on a mandatory preliminary (at the beginning of each session), also during the entire session (at a predetermined frequency), the characteristics of the SRTI are determined. Method takes into account both the basic variants of the transmitting part and the characteristics of the receiving part. Method is based on a system of developed decision rules, which, based on an analysis of the current characteristics of the SRTI, determine the appropriate type of content [16].

Information system of the dynamic formation of content

The main modules and users of information technology of dynamic content formation (Fig. 1) are implemented using the SDDC information system (system of the dynamic determination of content). Fig. 3 shows the use case diagram of the SDDC information system, which shows the main users, information system functions and their interaction with models and methods, on which the submitted information technology.

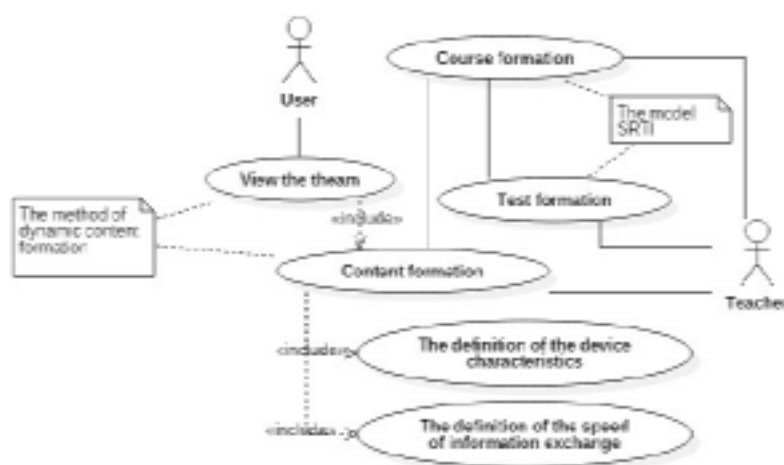


Fig. 3. Diagram of use cases of the information system SDDC of the dynamic formation content in real-time

Use of information system of dynamic formation of content

Two experiments were conducted to evaluate the developed information technology.

The first experiment was aimed at all stages of information technology, which include the model of the receiving part of the system of receiving and transmitting information, the basic model of content, the model of SRTI, and the method of dynamic formation of content, which are aimed at improving the quality of the process of receiving and transmitting information. The experiment was conducted among 132 students. Each student had to connect to a distance course and view 4 types of material (text, text with high quality images, text with low quality images, video, multimedia) using smartphones or laptops / PCs. According to the research, 47 % of the entire audience of students begins to take a distance course on the chosen subject with the help of smartphones or plans. Prior to the use of the developed technology, at the first connection, there were no problems with reproducing content for only 5% of users. At the same time, 37,6 % of all students switched from mobile devices to using PCs / laptops. After using the developed information technology, all students were able to obtain the necessary information on the course the first time. Only 3 % of student transfers from mobile devices to PCs were registered. At the same time, not a single student had any problems with reproducing content.

The second experiment was aimed at the formation of the test, because in addition to being built on an SRTI model, it also includes a method for assessing and increasing the representativeness of a test to ensure its quality, which is based on an analysis of the proportion of the number of questions covering different sections and educational objectives of the course.

To confirm the effectiveness of this stage, tests of three disciplines were analyzed. The representativity test inspection showed that a measure of conformance test for the first discipline is 1,25; for the second – 1,3; on the third – 3,6. Tests with such indicators have low representativeness and require a review of the number of questions on each of the topics. After that, the required number of questions for each topic was calculated using the method of assessment and increasing the representativeness of the test. When using this stage, it was practically established that the time spent on the work on calculating the characteristics of the test was reduced by 2 times.

Conclusion

The information technology of dynamic content formation in conditions of limited resources, which is implemented in the form of the SDDC (system of the dynamic determination of content) information system SDDC, which presented in this work, is designed for the dynamic formation of content courses using elements of distance learning, to ensure that all information is viewed regardless of the communication channel and student devices.

Information technology of dynamic content formation is based on the model of the receiving part of the system for receiving and transmitting information, the basic content model, the model of the system for receiving and transmitting information, and the method of dynamic content formation.

The developed information technology allows the user to receive such content that he can view using his device, even if the device has low characteristics, and / or if there is currently a poor communication channel. Most often, in such conditions, the user cannot get high-quality content: video is not loaded, high-quality images, there is no possibility to use multimedia. Especially often these problems arise among students due to their use of budget hardware.

In this work, the main stages of information technology of dynamic formation of content were identified and described, the connection of the stages of information technology with the models and methods on the basis of which information technology was developed, an information system is specified that was developed for the implementation of information technology for dynamic formation of content and the approbation of the developed information technology was performed.

Approbation of information technology was performed at the Odessa Polytechnic University in disciplines that use elements of distance learning to ensure that all information on the course is viewed, regardless of the communication channel and students' devices. Before using the developed information technology, 37,6 % of students switched from mobile devices to PCs: the quality of the RTI process is 62,4 % (however, many students who did not leave the course received poor-quality content - see experiment 2-3). After using information technology, only 3 % of students' transitions from mobile devices to PCs were recorded: the quality of the RTI process is 97 % (while students who left the course received the necessary content – see experiment 4).

The quality of the RTI process after using information technology has increased 1.55 times. The information technology thus developed ensures an improvement in the quality of the RTI process.

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ ДИНАМІЧНОГО ФОРМУВАННЯ КОНТЕНТУ В ЗАЛЕЖНОСТІ ВІД ХАРАКТЕРИСТИК СИСТЕМИ ПРИЙОМУ-ПЕРЕДАЧІ

Анотація. У даній роботі представлена інформаційна технологія динамічного формування контенту в умовах обмежених ресурсів. Завдяки розробленій інформаційній технології, при підключенні до сайту користувач буде отримувати інформацію в тому вигляді, який зможе відтворити його пристрій. Інформаційна технологія динамічного формування контенту складається з чотирьох етапів: формування курсу, формування тесту, визначення характеристик і відображення інформації. Етап формування курсу заснований на моделі системи прийому-передачі інформації, а саме на уявленні користувача і інформаційного ресурсу. Подання користувача включає в себе модель приймальної частини системи прийому-передачі інформації та тип користувача з точки зору прав доступу. Подання інформаційного ресурсу включає в себе базову модель контенту і безліч зареєстрованих користувачів. У свою чергу, базова модель контенту включає в себе контент, який складається з безлічі розділів, а кожен розділ може бути поділений на безліч елементів розділу. Етап формування тесту заснований на моделі системи прийому-передачі і містить оцінку репрезентативності тесту для забезпечення його якості, який заснований на аналізі пропорції кількості питань, що охоплюють різні розділи і навчальні цілі курсу. Етапи визначення характеристик і відображення інформації засновані на методі динамічного формування контенту. Основні модулі і користувачі інформаційної технології динамічного формування контенту реалізуються за допомогою інформаційної системи "System of the Dynamic Determination of Content". Апробація інформаційної технології була виконана в Одеському національному політехнічному університеті в дисциплінах, які використовують елементи дистанційного навчання, для забезпечення перегляду всієї інформації по курсу, незалежно від каналу зв'язку і пристроїв студентів. Для оцінки якості розробленої інформаційної технології був проведений експеримент за участю студентів. В результаті експерименту, було доведено, що якість процесу прийому-передачі інформації збільшилася в 1,55 разів за рахунок використання розробленої інформаційної технології.

Ключові слова: дистанційне навчання; мобільне навчання; контент; формування контенту; прийом даних; передача даних; динамічне формування контенту; обмежені ресурси

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ИНФОРМАЦИОННАЯ ТЕХНОЛОГИЯ ДИНАМИЧЕСКОГО ФОРМИРОВАНИЯ КОНТЕНТА В ЗАВИСИМОСТИ ОТ ХАРАКТЕРИСТИК СИСТЕМЫ ПРИЕМО-ПЕРЕДАЧИ

Аннотация. В данной работе представлена информационная технология динамического формирования контента в условиях ограниченных ресурсов. Благодаря разработанной информационной технологии, при подключении к сайту пользователь будет получать информацию в том виде, который сможет воспроизвести его устройство. Информационная технология динамического формирования контента состоит из четырех этапов: формирования курса, формирования теста, определения характеристик и отображения информации. Этап формирования курса основан на модели системы приема-передачи информации, а именно на представлении пользователя и информационного ресурса. Представление пользователя включает в себя модель приемной части системы приема-передачи информации и тип пользователя с точки зрения прав доступа. Представление информационного ресурса включает в себя базовую модель контента и множество зарегистрированных пользователей. В свою очередь, базовая модель контента включает в себя контент, который состоит из множества разделов, а каждый раздел может быть поделен на множество элементов раздела. Этап формирования теста основан на модели СППИ и содержит оценку репрезентативности теста для обеспечения его качества, который основан на анализе пропорции количества вопросов, охватывающих разные разделы и учебные цели курса. Этапы определения характеристик и отображения информации основаны на методе динамического формирования контента. Основные модули и пользователи информационной технологии динамического формирования контента реализуются с помощью информационной системы "System of the Dynamic Determination of Content". Апробация информационной технологии была выполнена в Одесском национальном политехническом университете в дисциплинах, использующих элементы дистанционного обучения, для обеспечения просмотра всей информации по курсу, независимо от канала связи и устройств студентов. Для оценки качества разработанной информационной технологии был проведен эксперимент с участием студентов. В результате эксперимента, было доказано, что качество процесса приема-передачи информации увеличилось в 1,55 раз за счет использования разработанной информационной технологии.

Ключевые слова: дистанционное обучение; мобильное обучение; контент; формирование контента; прием данных; передача данных; динамическое формирование контента; ограниченные ресурсы