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# *Approaches to the Electronic Textbook Development for Distance Learning*

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The paper focuses on electronic textbook development for distance learning. The paper contains approaches that allow creating a system for multimedia e-courses, including integration into information systems. E-courses allow you to train school students, professional students and higher educational institutions, employees of enterprises without conducting face-to-face events.

There are basic e-textbook features and open source distance learning systems such as Moodle, Open edX, Atutor, Ilias, and Diskurs. They extend the basic functionality and integrate into information systems. There are conclusions about the need to develop a new solution.

There are requirements for the electronic textbook and the development approach. The proposed solution is suitable for organizations that need to place distance learning tools inside their own information system or on the website. There are main features of the electronic textbook, the architecture, and the data storage model. As the main feature, it is possible to single out the Russian specific consideration in terms of checking expert opinions for the materials publishing possibility. The author tested the solution and highlighted the recommendations and guidelines for further research.

***Keywords:*** *distance learning, e-learning, learning management systems, electronic textbook, electronic course, web technology, information systems.*

## Introduction

Nowadays information and communication technologies are an integral part of human life. In this regard, there is a tendency for the development of electronic textbooks including multimedia materials and allowing to educate users anywhere and anytime [1].

An electronic textbook developing is a time-consuming problem. Therefore, there are existing distance learning systems (LMS) which may also have an integration mechanism which may be important for enterprises: sometimes it is necessary to have elements of e-learning inside information system.

Opportunities of LMSs are generally close and relying on them we can distinguish the basic functionality of electronic textbook:

- integrated editing of electronic textbook materials with their structuring possibility (dividing the course into topics, sections);
- adding materials for student theoretical training;
- adding practical training problems to consolidate the gained theoretical knowledge;
- creating, editing and conducting tests to evaluate the student preparation in the framework of the electronic course;
- reporting material formation based on learning outcomes [2].

Functionality should not go beyond the necessary capabilities. Otherwise, this can complicate the electronic textbook as a whole and user training to work with it [3]. Therefore, the use of ready-made LMSs is not always a universal solution when developing an electronic textbook.

Users (organizations, schools, and professional and higher education institutions) need simple and effective management of the learning process. This consists of introducing training materials in the training process with almost no labor efforts on the part of the teacher, with the generating report possibility on learning outcomes and “seamless” integration into information system [4, 5]. Integration should be carried out not only at the level of the user interface, but also allow the electronic textbook and information system to exchange data [6].

## Existing solutions

LMS must have basic functionality. Open-source systems have a selection based on the frequency of their mention in papers, reviews and ratings of these systems users. There were papers with a minimum citation of the order of 20 (according to Google Scholar) for the period 2008-2019.

**Moodle (moodle.org)**

Moodle is a modular web-based e-learning system that supports popular standards in e-learning: IMS, AICC and SCORM. There is the opportunity to post multimedia materials in an electronic course. Moodle lacks a built-

in educational content designer. There are built-in user management and reporting system. It has module sets that allow the user to change the course-specific system. In addition to working with electronic courses, there is a working possibility with events, news, forums. Installation requires PHP support and Apache or Nginx web server. It can use such DBMSs as MySQL, PostgreSQL, etc. [7-9].

**Open edX (open.edx.org)**

Open edX web platform offers opportunities for posting training material and monitoring course passing. It has the ability to expand the functionality for creating training tools with which you can change the system according to the needs of users. The platform has built-in user control and management system. For the installation server it's better to use Ubuntu 16.04 and Nginx web server. It can use DBMSs such as MySQL, Memcache, Mongo [10].

**ATutor (atutor.github.io)**

ATutor is a web-based e-learning system with an integrated course editor. There is support for such popular standards in e-learning as IMS and SCORM, forums and a subsystem for the monitoring user activity. You can create courses, tests, webinars and collect statistics using ATutor. The platform has built-in user control and management system. It is developing by the community on GitHub. Installation requires PHP support, Apache web server, MySQL DBMS [11].

**Ilias (www.ilias.de)**

Ilias is a web-based e-learning platform with an integrated course editor. In Ilias you can upload and create training materials. In addition to the functionality of editing courses in the system, there are notification and communication tools: forums, discussions, newsletters, friend lists. The system has wiki tools and tools such as "Personal Workspace", "Personal Notebook", "Electronic Portfolio", "Calendar", "News", etc. The interface and functionality can be changed using additional modules. There is support for IMS, SCORM e-learning standards. The platform has built-in user control and management system. Installation requires PHP support, Apache web server, MySQL DBMS [12].

**Diskurs (diskurslms.ru)**

Diskurs is a web-based e-learning platform with the integrated course editor. Among the features we can distinguish the number of templates and blanks - about 40-course material types including multimedia content. There is support for IMS, AICC and SCORM e-learning standards. The platform has an integrated user control and management system and paid interface customization. Installation requires PHP 7.1 support.

**Comparison Results**

The reviewed LMSs can be used as an electronic textbook. You can edit textbook content, test users and keep track of learning outcomes. Each candidate can cover almost arbitrary requirements for electronic textbook through the use of off-the-shelf modules (except for Atutor and Diskurs) and can be integrated into the information system.

However, Moodle, Open edX, and Ilias are not suitable for developing an electronic textbook, as their functionality is much wider than the basic functionality. This complicates the learning and use process. User will have to study the settings and develop their own software modules that are why the integration process may be more time-consuming than the new software platform development.

In this regard, open-source LSM is not always a suitable solution and it is expedient to develop your own solution for distance learning organizing with the possibility of integration into the information system.

**The Electronic Textbook Requirements**

Based on the reviewed LMSs and the basic functionality of the electronic textbook it is possible to present implementation requirements. The solution should be a web application that allows you to create educational electronic courses with the following functionality.

Electronic textbook users should have different access rights to system elements.

Teachers should have the right to create courses, fill them with multimedia materials and to form tests. They should be able to invite students to their class and courses with the ability to control performance and grades adjust.

Pupils should have access to all courses with the opportunity to enter anyone, study theoretical materials, solve practical problems, see course progress and perform tests.

The electronic textbook should have a built-in editor for the course content. The course should consist of topics that consist of sections that consist of subsections that contain course materials. Themes, sections, subsections should have a certain order with positioning relative possibility to each other. Course materials are hypertext pages with text, tables, images, formulas, links, videos, two-dimensional multimedia flash-objects, three-dimensional objects, with the ability to rotate and highlight the object part. Materials can be either theoretical or practical. Some problems may be hidden from the student, for the subsequent additional purpose to test. The electronic textbook should have a test constructor that allows you to select any tasks from the course and configure the date and time of opening.

**The Electronic Textbook Architecture**

There was system architecture based on the requirements. The "Layers" architectural template is for its presentation, with the help of which client-server architecture is demonstrated. In a client-server architecture,

system functionality has abstraction layers - presentation, application, business logic and data access layer as is usual when describing large systems [13]. There is electronic textbook architecture in Fig. 1.

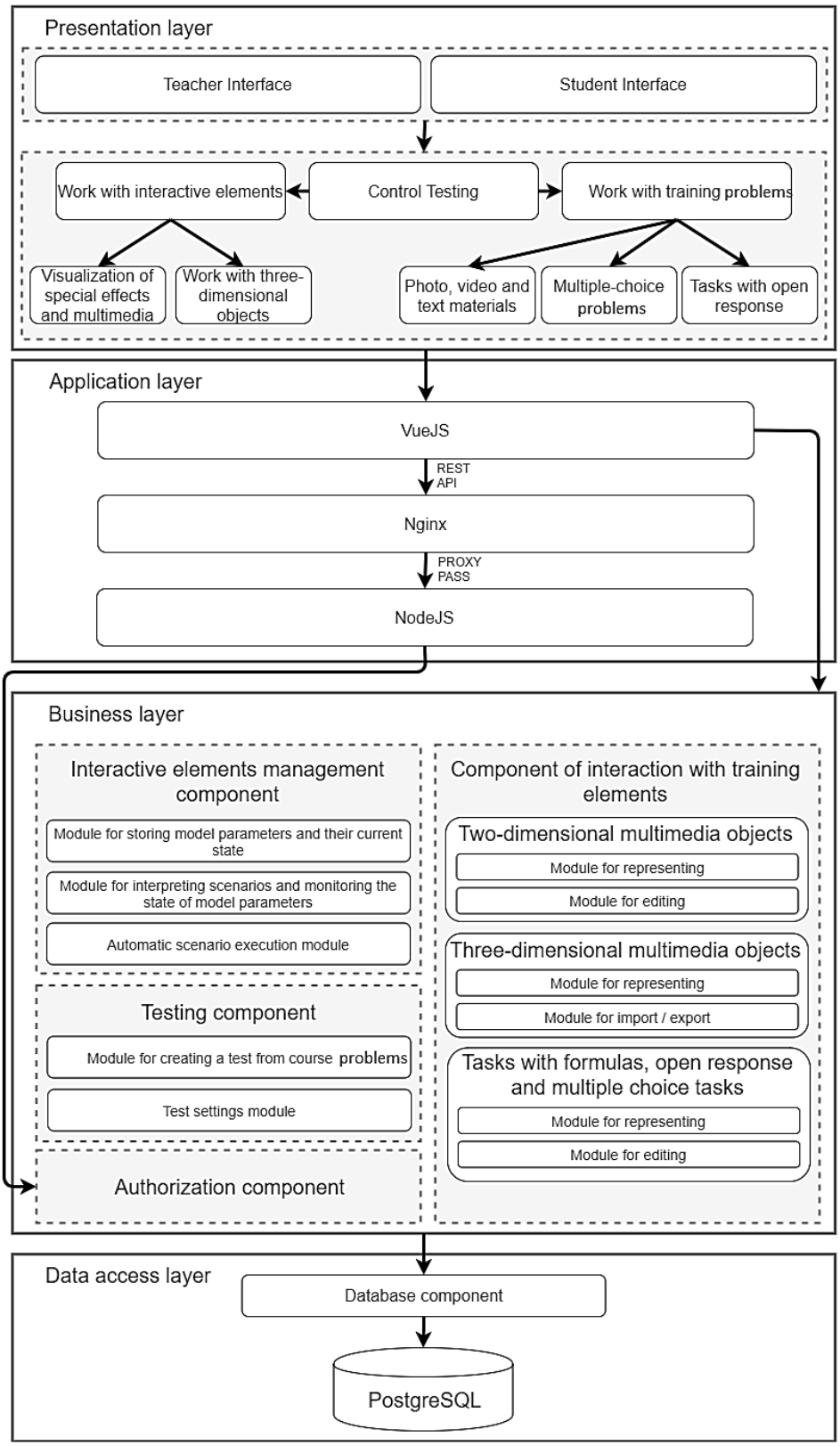


*Fig. 1. The electronic textbook architecture*

The presentation layer contains student and teacher basic elements of the interface. The student learns materials with multimedia elements, works on problems and solves tests that consist of course problems (some problems may be hidden in the course). The teacher fills the course with materials using the built-in editor and compiles tests using the test designer.

Vue.js JavaScript framework is responsible for creating and displaying student and teacher interfaces. The server runs the Node.js software platform which provides the REST API implemented using Express framework. Nginx web server acts as an intermediate member which redirects requests from Vue.js to the REST API.

The main business logic of the electronic textbook runs on the client-side (Vue.js). In the interaction component with training elements modules that are responsible for displaying and editing course material. The component for managing work with interactive elements contains modules that are necessary for creating and completing problems with flash-elements. For example, using this component you can create a mimic. For the created mimic it is necessary to store its parameters, execute the given scripts based on the current state of the parameters, and provide for the possibility of automatic scripts, to demonstrate to the student the correct sequence of actions. The component for creating control tests contains a test constructor module that allows you to select problems from the course and module that allows you to edit test settings.

Let's consider the proposed solution integration in the "Gazprom-classes" information system (gazprom-classes.etu.ru), which has a feature regarding a content publication on the site. The content verification specialist must check any materials and approve them for publication. The material verification cycle is in the state diagram (Fig. 2).

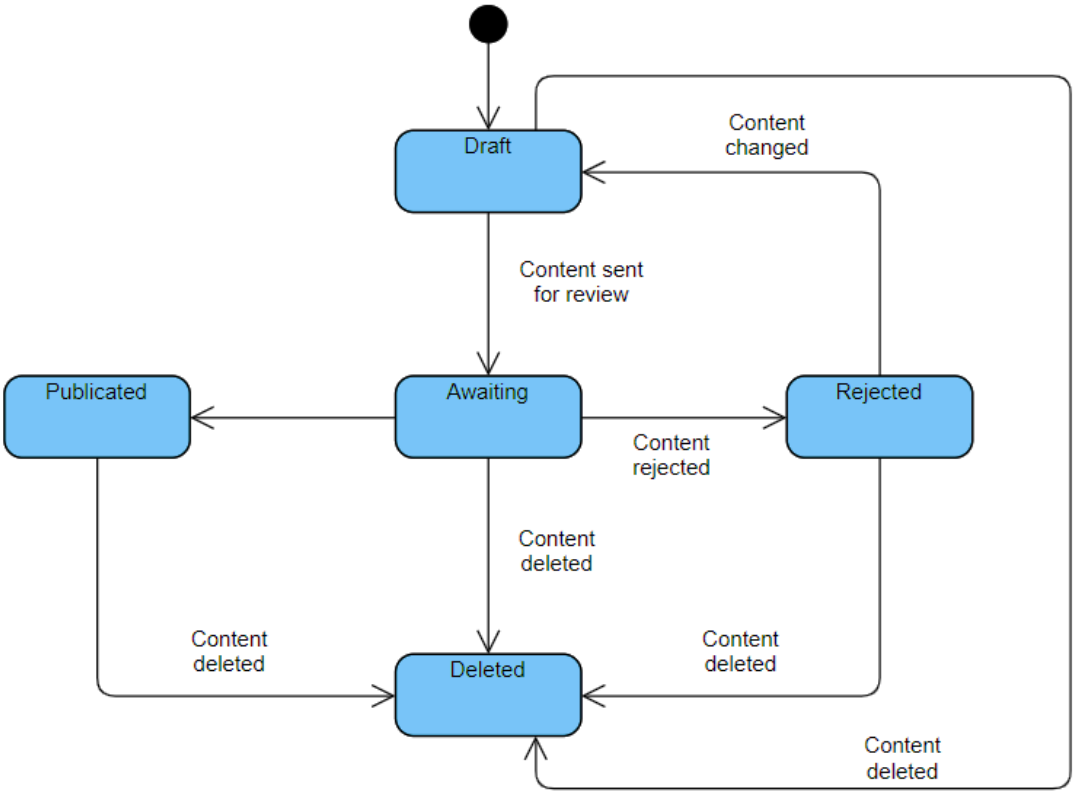


*Fig. 2. Content publication cycle in the "Gazprom-classes"*

In "Gazprom-classes" the information system content manager is engaged in editing materials and a classroom teacher has a teacher role. The administrator adds students and classroom teachers can add students also. The main user interaction of "Gazprom-classes" in the framework of working with an electronic textbook is in the sequence diagram (Fig. 3).

The content manager creates a course that receives the draft status (Fig. 2) and sends it for review to a content verification specialist who decides on the publication possibility. Both the content manager and the classroom teacher can create tests in the course. The classroom teacher can invite students to course, the form is in Fig. 4.

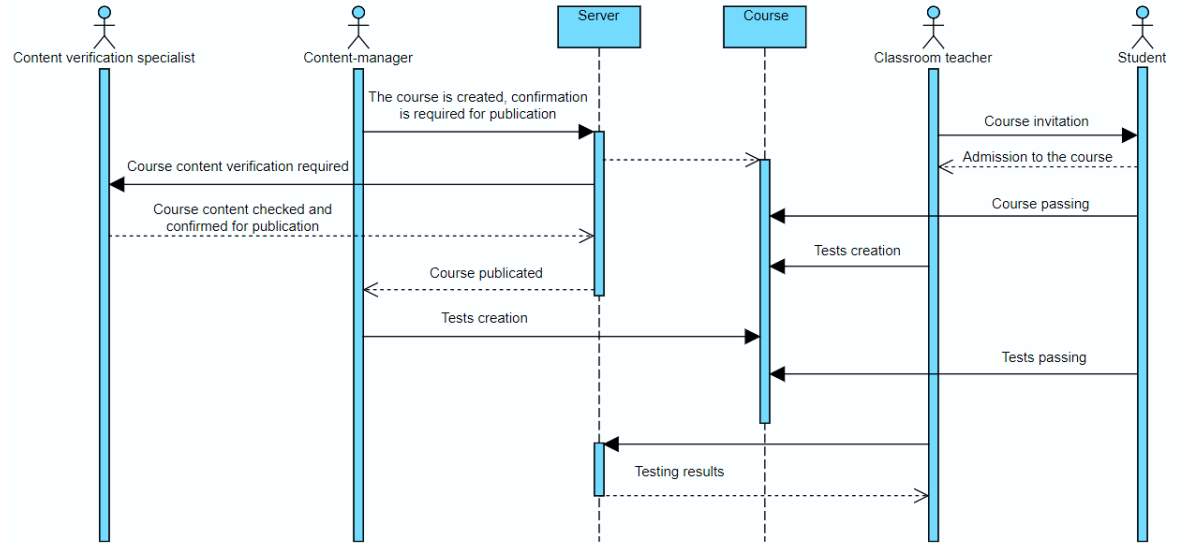


*Fig. 3. The main "Gazprom-classes" users interactions of the electronic textbook*

Students can study course materials, carry out course problems and take tests as well as see their course progress and grades for tests. The classroom teacher can receive data on their students' performance and adjust their grades if necessary. A test report example is in Fig. 5. The test report displays correctly identifiers and incorrectly completed tasks with the ability to view the student's response.

| Course invitation | | | | |
|---|---|---|---|---|
| MBEI Gymnasium | | | All | |
| Surname | Name | Middle name | Class | Participation |
| Vlasova | Anna | Andreevna | 10 | Entered |
| Kulikov | Vyacheslav | Maksimovich | 10 | Entered |
| Fedorova | Nina | Denisovna | 10 | Entered |
| Artem'eva | Rimma | Valerievna | 10 | |
| Veselova | Uliana | Denisovna | 10 | |
| Send invitations | | | Cancel | |

*Fig. 4. Students invitation to course form*

| Test report | | | | | |
|---|---|---|---|---|---|
| MBEI lyceum № 1 town Yuzhno-Sakhalinsk | | | | | All |
| Surname | Name | Middle name | Correct answers | Mark | Report |
| Baranova | Varvara | Antonovna | . | . | . |
| Belozerova | Valentina | Viktorovna | 1/8 | 2 | |
| Davidova | Zhanna | Romanovna | 1/8 | 2 | |
| Emelianiva | Anna | Stepanovna | . | . | . |
| Ershova | Uliana | Grigorievna | 0/8 | 2 | |

*Fig. 5. Students test results*

The electronic textbook basic algorithm in the «Gazprom-classes» information system is in the activity diagram (Fig. 6). The electronic textbook displays to the user a list of all electronic courses with a search bar by name. Also, there is a filter showing courses for which a student has already entered. There is a course title, brief description and contents before entering. Transition to any subsection is available after admission to the course. The course example is in Fig. 7.

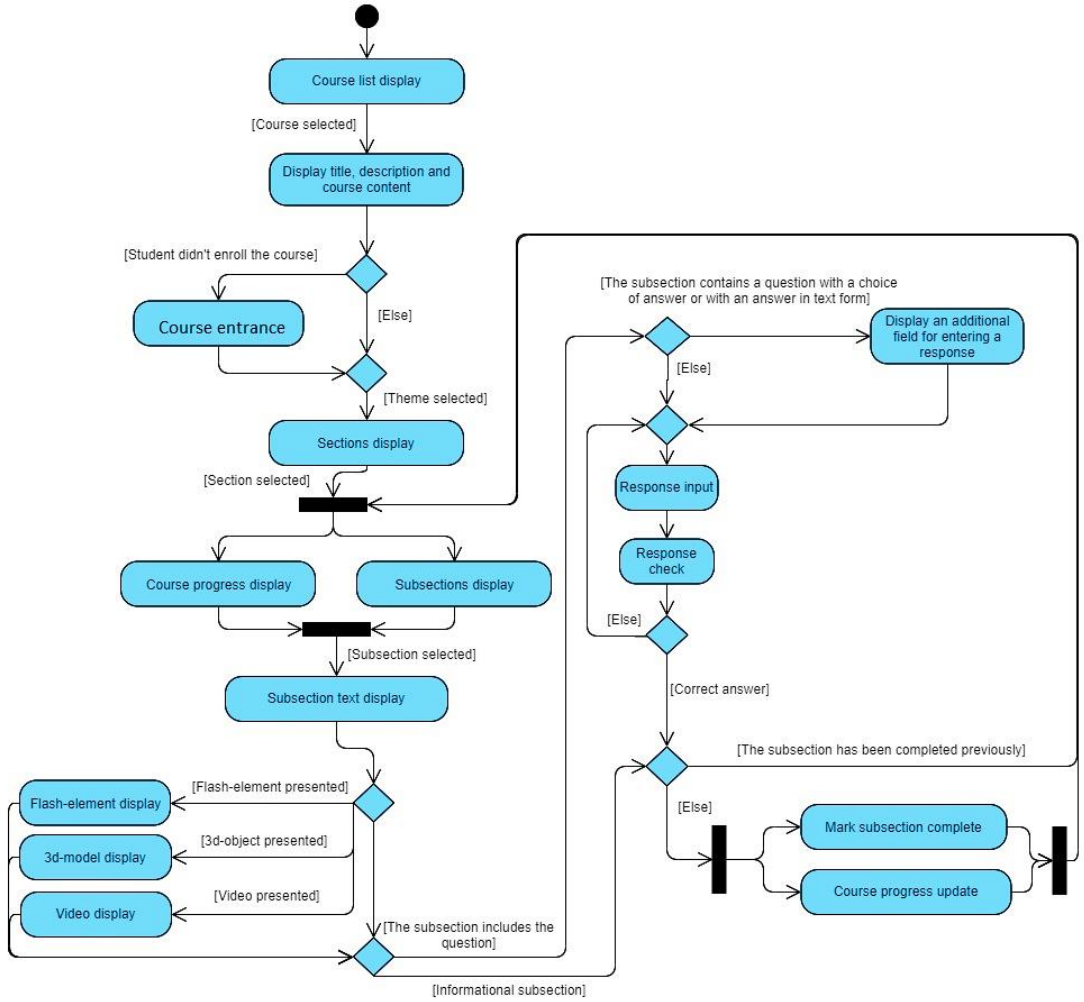


*Fig. 6. The electronic textbook basic algorithm*

**<Look for animated gif attached to the text>**

| | |
|---|---|
| Valentina Zueva | Theme 1. Strong cover yet list son, |
| Student | Section 1. Prove run question chance financial training either speak. |
| Back to the Menu | General Knowledge |
| Marks | Which of these does NOT manufacture automobiles? |
| Passed | Select possible answer(s) |
| Content | Nissan |
| Theme 1. Strong cover yet list son. | GMC |
| Section 1. Prove run question chance financial training either speak. | Fiat |
| Section 2. Keep issue ago culture senior clear heart measure. | Ducati |
| Section 3. World heavy Cover family generation Past himself treat. | |
| | Answer |

*Fig. 7. Course content*

**Structures**

To store data takes into account the possibility of embedding in information systems. The ER-model is in Figure 8. The model is a database physical structure based on a relational data model that involves integrity constraints of data type levels, relationships and database. However, some integrity aspects had violations during model construction in order to reduce memory consumption and the number of join operations to speed up query processing. Therefore, integrity support has partially supported at the application level.

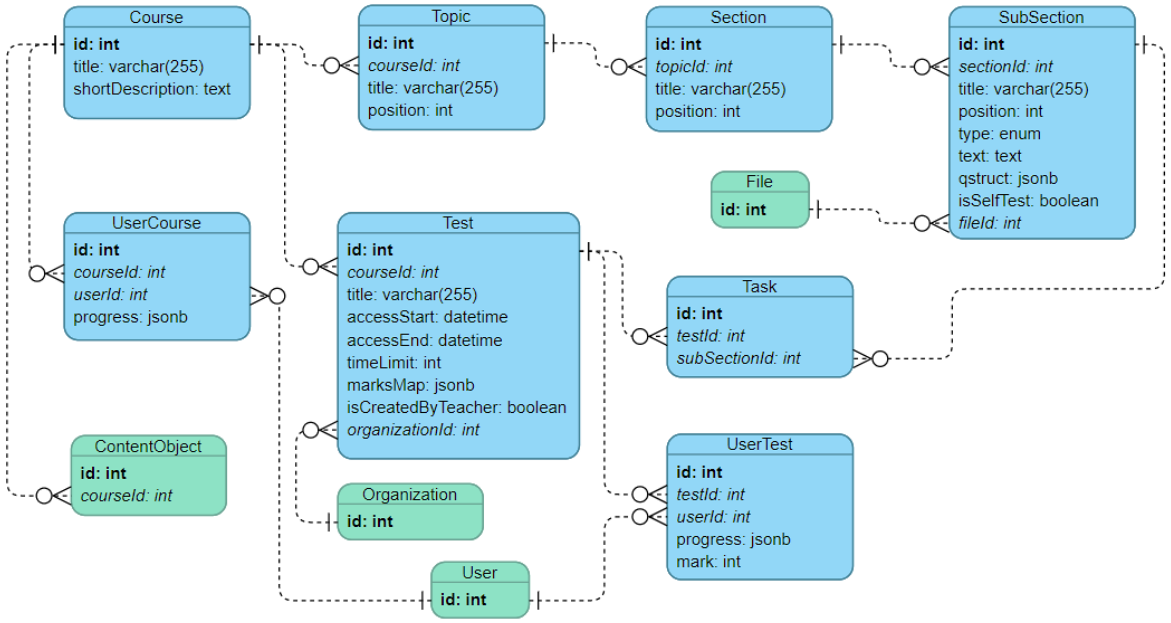


*Fig. 8. the electronic textbook ER-model*

The course has a name, brief description and “ContentObject” from the “Gazprom-classes” information system to implement the publication process (Fig. 2). The course contains a certain set of topics each of which has name and position relative to other topics. The topic consists of sections, sections consist of subsections. Sections and subsections have fields similar to the topic. Subsection may be informational or a problem. This information is in the “type” field and not in separate tables to simplify the structure and database queries. In any case, the subsection may contain text. If subsection contains the problem, its description is as JSON (JavaScript Object Notation), because building a static structure is almost impossible due to the fact that job descriptions can vary depending on the type. For example, subsection containing problem with answer selection might look like this:

```
{
 "question": "What is the smallest independent country on Earth by area?",
 "variants": ["Monaco", "Nauru", "Vatican City", "San Marino"],
 "answer": "3"
}
```

The jsonb type in PostgreSQL stores JSON data in binary form, not as text, reduces the amount of data and speeds up the search by storing information in a search-friendly format (using indexes and removing spaces). A file (video, flash, a three-dimensional object description) from the "Gazprom-classes" information system can be attached to the subsection.

Course data is in the “UserCourse” entity. Because strict consistency of data at the database level regarding progress on course is not necessary (integrity is at the application level), it is as JSON, where the key is the identifier of the subsection, and the value is “true” or “false”:

```
{
 "1": true,
 "2": true,
 "3": false
}
```

This leads to faster execution of database queries by reducing the number of connections.

Tests have a connection to the course and have a name and following settings: date and opening access time, closing access to the test, time limit in minutes for the test, JSON with the grades distribution by the number of problems (“marksMap” field) where the key is the grade, and value is the required number of correct problems:

```
{
  "5": 10,
  "4": 8,
  "3": 6
}
```

To differentiate access user identifiers could be but to simplify database queries the “Test” entity stores a link to the organization and the “isCreatedByTeacher” state which indicates whether the teacher has created test.

Test problems are links to subsections of the course. Test progress data is stored similarly to course progress data and there is a field for storing test grade.

## Conclusion

In the paper course, there were approaches to the electronic textbook creation for distance learning. There were open-source code LMSs and we concluded that ready-made solutions may not be suitable for organizing distance learning in the information system framework due to insufficient or excessive functionality.

The developed electronic textbook has a built-in course content editor and allows you to create multimedia electronic courses, conduct students testing and monitor academic performance. The program disadvantages include the extension subsystem lack, a limited course problem type’s number and limited reports number for teachers as well as the support lack for the SCORM electronic course standard. Therefore, to add a new problem type or report you must modify the system. There are no such restrictions in Moodle and Open edX.

The electronic textbook has been tested in the “Gazprom-classes” information system (gazprom-classes.etu.ru). The course "Gazpromovedenie" created by content managers and published by content verification specialists successfully.

As a further development of the solution, it is proposed to introduce gamification and an achievement system [14], an extension subsystem for the possibility of creating diverse reports with a statistic variety.

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# Подходы к разработке электронного учебника для дистанционного обучения

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Статья посвящена разработке электронного учебника для дистанционного обучения. Описаны подходы, позволяющие сформировать систему, с помощью которой создаются мультимедийные электронные курсы, в том числе с интеграцией в информационные системы. Электронные курсы позволяют обучать дистанционно учеников школ, студентов профессиональных и высших учебных заведений, работников предприятий.

Выделены базовые возможности электронного учебника и рассмотрены системы дистанционного обучения с открытым исходным кодом, такие как Moodle, Open edX, Atutor, Ilias, Diskurs. Такие системы расширяют базовую функциональность и могут быть интегрированы в информационные системы. Сделаны выводы о необходимости разработки нового решения.

Сформулированы требования к электронному учебнику и описан подход к разработке. Предложенное решение ориентировано на организации, которым необходимо разместить средства дистанционного обучения внутри собственной информационной системы или на сайте. Выделены основные возможности электронного учебника, приведены архитектура и модель хранения данных. В качестве основной особенности можно выделить учет российской специфики в части проверки экспертных заключений на возможность опубликования материалов в открытой печати. Выполнена апробация решения, выделены ограничения и направления дальнейшего развития.

***Ключевые слова:*** *дистанционное обучение, e-learning, системы управления, электронный учебник, электронные курсы, web-технологии, информационные системы.*

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