LEARNING MANAGEMENT SYSTEM WITH SCHEDULING FUNCTIONS

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Abstract: *In this paper, we investigated the problem of scheduling for the School Management System (Learning Management System, LMS) and proposed our solution to solve it. We articulated that change management is also an essential part of the system. The comparative analysis of standards for LMS, courses learning materials representation and well-known LMS was done and presented in this research. IEEE LTSC, AICC, IMS, ADL, SCORM, ARIADNE and other standards were inspected with regard to the systems where they are implemented. The conclusions were made based on the gathered and presented material. The new system developed and implemented in a number of educational institutions was presented in this work. The research is illustrated with the images of particular systems as well as the comparison table and brief information blocks to systemize the material representation.*

Keywords: *e-learning, learning management system, IEEE, LTSC, AICC, IMS, ADL, SCORM, ARIADNE, LMS, CMS, SMS, MOODLE, Claroline, Dokeos, ATutor, ILIAS.*

ITHEA Keywords: *J.1 Computer Applications - ADMINISTRATIVE DATA PROCESSING - Education, K.3.1 Computing Milieux - COMPUTERS AND EDUCATION - Computer Uses in Education, H.4.1 Information Systems - INFORMATION SYSTEMS APPLICATIONS - Office Automation - Time management (e.g., calendars, schedules)*

Introduction

Learning Management Systems (LMS) and its variants emerged as further development of Content Management System (CMS), a kind of specialized systems, in particular for learning management.

In the literature, one can find the following abbreviation for learning management systems:

- LMS - Learning Management System,

- CMS - Course Management System,

- LCMS - Learning Content Management System,

- MLE - Managed Learning Environment training),

- LSS - Learning Support System,

- LP - Learning Platform,

- VLE - Virtual Learning Environments.

The most common are LMS and CMS (not to be confused with the content management system).

Learning Management Systems (LMS) are very popular today, also known as e-Learning systems. They really cover many functions of the study process and its organization.

Here we will look through the most popular Learning Management Systems and argue the new development with relatively new important functions omitted in other systems.

A Brief History of E-Learning Development.

The LMS is defined as a software application designed to administer, monitor, document, provide educational content, and control e-learning and training courses. These systems are popular in colleges and universities but can also be used by businesses and other organizations.

In schools, LMS is often used as a supplementary online education or supplementary classroom resource. These software solutions can also be sought after by businesses as tools for corporate training, certification and accounting.

Every LMS, a learning management system, has its own unique set of features. This is what differentiates each product. At the same time, although the features may differ, there is a certain standard set of features and settings that are most common and present in virtually any LMS. This set typically solves basic learning tasks such as enrollment, educational achievement monitoring, planning, content management, communication, and teamwork. Some systems offer other attractive features, such as mobile access and e-commerce.

The effective use of information technology in education significantly improves the effectiveness of learning and reduces its costs.

The research conducted in this area most often compares group and individual training. In this regard, the following features were observed:

- on average, group has about 0.1 questions per hour per student [LTSC];

- in individual study the student can ask or answer 120 questions per hour [LTSC];

- for 98% of students, the efficiency of individual work is higher by 50% than in the group [LTSC].

There are many official LMS standards available today, so the product selection decision is up to the users and/or their companies to maximize their satisfaction. What works great for some organizations may not work for others at all. Let's go into details.

Review of standards.

A standard is a format approved by a recognized standardization institution or accepted by industry (or the majority of interested representatives) as a de facto sample.

There are standards for programming languages, operating systems, presentation formats, communication protocols, electronic interfaces, etc. Having standards is important for any IT user, as it is through standardization. The availability of standards is important for any IT user, because it is through standardization that each user can combine the equipment and programs of different manufacturers according to their individual needs. If there is no single standard, then the user should be limited to devices and applications from only one manufacturer. Both hardware and software, in particular, e-learning applications, are subject to standardization.

The most common standards in e-learning include:

- IEEE - Institute of Electrical and Electronic Engineers (LTSC - Learning Technology Standards Committee) (http://ltsc.ieee.org/) [LTSC]
- AICC - Airline Industry Computer Based Training Committee (Http://www.aicc.org) [AICC]
- IMS - Instructional Management Systems, World Education Consortium - IMS Specification - XML-based standard describes the course structure. (http://www.imsproject.org) [IMS]

- ADL/SCORM - Advanced Distributed Learning and the ADL SCORM standard - Sharable Content Object Reference Model (http://www.adlnet.org/) [ADL SCORM, SCORM]
- ARIADNE - Alliance of Remote Instructional Authoring & Distribution Networks for Europe (http://www.ariadne-eu.org/) standardizing the exchange of educational content for the European Union.
- PROMETEUS http: //www.prometeus.org/
- The Dublin Core Metadata Initiative http://dublincore.org/

SCORM - Sharable Content Object Reference Model.

The creation of the SCORM standard [ADL SCORM] was the first step in the development of the ADL [ADL] concept. This standard defines the structure of the training materials and the runtime interface, whereby training objects can be used in various electronic distant education systems.

In SCORM, this technical structure is described using some basic principles, standards and specifications based on the work of other already established specifications and standards for e-learning and distance education. Organizations that have established the relevant standards continue to work with ADL, developing and improving their own e-distance and eLearning specifications and standards, and helping to build and improve SCORM.

ADL has created SCORM to integrate different standards and specifications (such as LOM, IMS CP) into a single content model. SCORM is a technical infrastructure that allows you to share objects in a distributed learning environment. An exemplary Sharable Content Object Reference Model (SCORM) defines a model for content aggregation and a work environment for web-based learning objects.

Initially, it was a set of manuals and technical descriptions. Subsequently, a number of organizations joined the process and the project became more versatile (including, for example, the use of CDs, interactive multimedia, etc.).

SCORM uses the results of a number of projects and organizations such as: IMS Global Learning Consortium, Inc., the Aviation Industry CBT (Computer-Based Training) Committee (AICC), the Alliance of Remote Instructional Authoring & Distribution Networks for Europe (ARIADNE) and the IEEE Learning Technology Standards Committee (LTSC).

Version 1.2 of SCORM introduces the concept of content packaging and contains updated metadata for describing training content based on specifications created by the IMS Global Learning Consortium and IEEE LTSC.

SCORM is widely recognized among all e-learning standardization products. This model is used to create training systems that rely on Internet resources.

The standard SCORM model consists of three parts:

- the introduction or the overview (the Overview);
- a description of the content integration model (the Content Aggregate Model);
- a description of the workspace or the RunTime Environment (RTE).

The first part describes the ADL standards and provides a rationale for creating a reference model. The second part provides practical tips for identifying resources and transforming them into structured learning material. The last part gives practical tips for communicating with the web environment and tracking its content. In an ideal SCORM-compliant situation, all curriculum elements are functionally compatible with all LMS systems and VLE environments. Any standard training computer program can be introduced into an existing training organization / virtual environment and data will be shared between them.

Rather, SCORM is not a standard, but a benchmark to test the effectiveness and practical applicability of a set of individual specifications and standards. This benchmark is used by standards developers such as IEEE and IMS to integrate the specifications they have created.

The main features of e-learning solutions

When choosing software for training systems, the following characteristics can be considered:

- reliability in operation,
- security,
- compatibility (including compliance with standards),
- ease of use and administration,
- modularity,
- access providing,
- the cost of software, maintenance and hardware needed.

It is important to note that many of them overlap. However, examining them individually helps to understand the technical requirements for training systems.

Reliability in operation

This parameter characterizes the ease of administration and ease of updating content using existing templates. When choosing software, make sure that the content of the training course and the site structure are separated so that you cannot accidentally delete important menu items when updating content. Check the help system and make sure it is really helpful.

It is advisable that you do not depend on the mercy to the seller when operating.

If it is difficult to add new users to the system, exclude old users, add content, have problems updating the site, etc. teachers quickly refuse to use it.

Compatibility

The prosper system must be compatible with other e-learning solutions. Although a "universal" software solution that fits all possible, there are no universal and all-needs-covering standards, but you can still choose a system that supports at least one widespread standard. Otherwise you will be connected with developers of the system from the time of its installation until the end of life.

When compatibility may be required:

- Sharing (moving) content from one learning management system to another.
- Use of developed courses.
- New employees (non-standard systems require trainings).

One way to ensure compatibility is to look for software that supports industry-specific standards. Ideally, it should allow the use of the same training materials in different learning management and content management systems. Compatibility is the ability to take the same training material and, without making changes, use it in different learning management systems. Currently, standards are just a general direction for achieving compatibility. It should not be assumed in advance that a SCORM-compliant training course can be automatically used in a SCORM-based learning management system.

Ease of use and administration

When choosing a new system, it is necessary to ensure its convenient usage. This is an important parameter as potential students will never use technology that seems cumbersome or difficult to navigate. Teaching technology should be intuitive. The training course should be simple to find the help menu, easy to navigate from one section to another and communicate with the teacher.

Teachers, in turn, are not inclined to read a thick guide to using the courseware or to spend time figuring out how to create a test. The software should be simple and better open sourced.

Modularity

Modern systems of additional training often use small interchangeable objects of knowledge - small elements of educational content. These are small, self-contained information blocks that can be reused for educational purposes. They are often compared to the elements of the Lego game. Knowledge objects can simply be transferred from one course or lesson to another, completely different from it. The purpose of creating these objects is to reduce the development time of courses, because by creating one object, it can be reused again and again.

Such blocks can be joined, separated and arranged in different order, regardless of their size or color.

If you intend to use such "cubes", it is necessary for the system of your choice to support this kind of functionality, that is, to allow you to identify the objects of knowledge and to allow the course organizer to associate the objects of knowledge with the learning objectives.

Providing the access

There are two aspects to this question. The first is that those who are taught should have no barriers to accessing the curriculum. For example, it should be compatible with screen readers, programs that can read words on the screen for those who have low vision.

The second aspect is to make sure that the technology you purchase is suitable for all potential users. For example, if some of the students do not have the

latest version of Macromedia Flash, they will not see the animation you created with the technology.

Purchased software should be tested with those browsers that will be used by those who are being trained. In order to make sure that the training program runs on the platform on which it is required, several scenarios must be tested. Test on multiple computers with different browsers and programs, or you need to give rigid hardware configuration recommendations.

Cost of software, maintenance and hardware

An important aspect is the price.

When calculating the price one should take into account the following:

- Cost of all software including: the system itself; operating system; DBMS; anti-virus programs; security software etc.
- Support. It should be borne in mind that different software requires different levels of skill and salary. It all should be calculated.
- The cost of the hardware, including server; power consumption; data backup system; network and channel facilities; redundancy for hot and cold replacement of equipment in case of failure.

Overview of learning management systems

MOODLE

MOODLE [MOODLE] is one of the most widely used LMS. MOODLE allows you to create a private online learning space filled with exciting activities and materials. You will always have full control over all your data and the way your

employees, students and clients are on board. MOODLE design and development are guided by a particular teaching philosophy, which can be briefly called "social constructionist pedagogy" (**Fig. 1**).

MOODLE: Brief information

MOODLE - Modular Object-Oriented Dynamic Learning Environment.

Current Version: 3.8.1

Official site: https://moodle.com/lms/

Support: IMS / SCORM specifications

Platform: PHP, MySQL, PostgreSQL

License: GNU General Public License (GPL)

Supports many languages

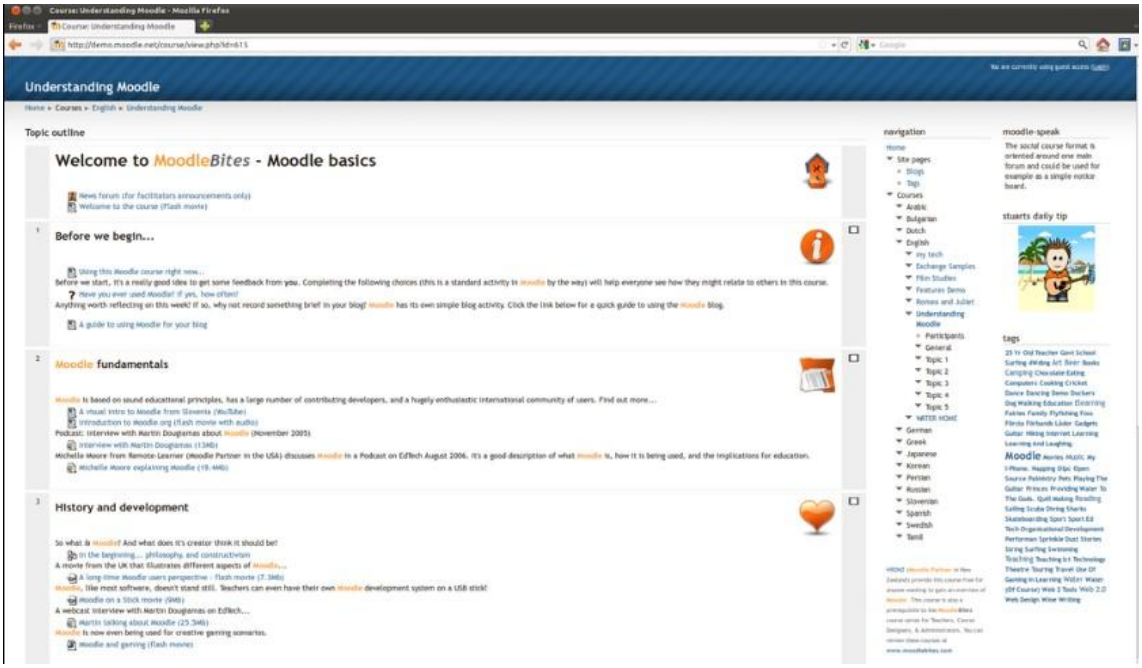

Fig. 1. MOODLE

Claroline

Claroline [Claroline] is a collaborative e-learning and e-work platform, licensed under the open source GPL. The application was created in Belgium at the Institute of Pedagogy and Multimedia of the Catholic University of Louvain. The Claroline Connect project aims to be a technology-driven project. Meeting the actual standards imposed by web giants such as Google, Facebook, and more.

So, today Claroline is being developed in React and Symfony. Claroline LMS is available in 35 languages and is currently used in more than one hundred different countries by organizations, universities, or schools to manage their e-learning resources.

Claroline offers a number of tools and features that allow the teacher to manage their courses and students. They can download files in various formats, such as PDF, HTML, or video, which will complement the course description, create exercises and timetables **(Fig. 2**). Other features include managing your students by creating user groups and checking attendance and exercise statistics.

Claroline: Brief information
Official site: www.claroline.net
Current Version: 12.0.1
Support: IMS / SCORM
Operating System: Windows, macOS, Linux
Specifications Application languages: PHP, JAVA, React and Symfony
License: GNU General Public License (GPL)
Language: English, French, Spanish

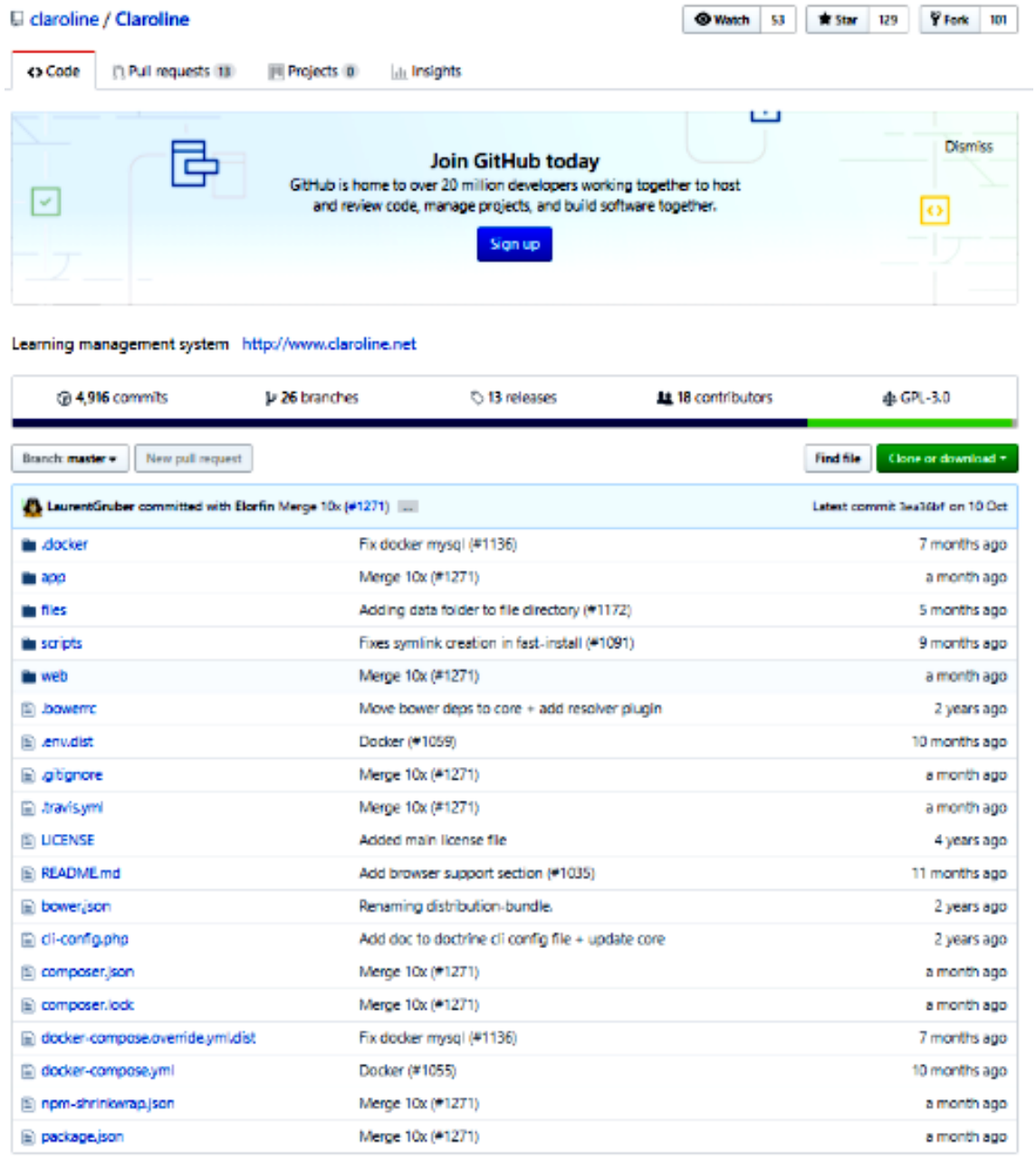

Fig. 2. Claroline

Dokeos

Dokeos [Dokeos]. A distance learning platform for Claroline branch fork (version 1.4.2.). A branch is a clone of a freely distributed software product designed to change an original application in one direction or another.

Dokeos is the result of the work of some members of the original Claroline development team who conceived change the orientation of the application. Now it is more appropriate for organizations than for universities.

The fact is that Claroline is perfectly adapted to the university environment, which is expressed in support of a large number of students and courses. Dokeos, we think, is more focused on a professional clientele, for example, company staff.

Developers wanted to organize (rather to put up for sale) a set of additional services for the platform. The name Dokeos refers to both the application and the company that offers a range of different services to the platform: hosting, content integration, development of additional modules, those. support etc.

Dokeos is free because the Claroline License (GNU / GPL) stipulates that branches are subject to the same license. Since the branch was recently highlighted, both applications are now relatively similar to each other, although some differences in ergonomics, interface design and functionality are already beginning to emerge.

An example of Dokeos implementation is the Ghent University.

Dokeos: Brief information
Official site: www.dokeos.com
Support: IMS / SCORM
Platform: PHP, MySQL
License: GNU General Public License (GPL)
Ukrainian language support: yes
Demo site: http://demo.opensourcecms.com/dokeos/

ATutor

ATutor [ATutor] is also a web-based LMS. The software is easy to install, configure, and support for system administrators. Teachers (instructors) can easily create and upload tutorials and run their online courses. Since the system is modular, and it consists of separate functional units - modules, then it is open for modernization and expansion of the functionality.

The system was created by Canadian developers. Includes all the necessary e-learning tools. There is a Ukrainian version also.

ATutor: Brief information
Official site: www.atutor.ca
Support: IMS / SCORM
Current Version: 2.2.1
Program languages: PHP, JAVA
DBMS: MySQL
License: GNU General Public License (GPL)
Ukrainian language support: yes
Demo site: http://www.atutor.ca/atutor/demo/login.php

ILIAS

ILIAS [ILIAS] is a free LMS to support the learning process. The system is widespread in universities, especially in Germany. ILIAS stands for Integrated Learning, Information and Work Cooperation System. The idea behind ILIAS is

to offer a flexible environment for learning and working online with integrated tools. ILIAS goes far beyond the idea of learning being confined to courses as a lot of other LMS do. ILIAS can rather be seen as a type of library providing learning and working materials and contents at any location of the repository. This offers the possibility to run ILIAS not as a locked warehouse but as an open knowledge platform where content might be made available for non-registered users too.

ILIAS: Brief information

Official site: www.ilias.de/ios/index-e.html#ilias

Support: SCORM

Minutes: CAS, SOAP, RADIUS, LDAP, Shiboleth authentication

Current Version: 5.3.10

Application languages: Apache, PHP, MySQL, XML.

License: GNU General Public License (GPL)

Multilingualism, support for the Ukrainian language

Comparison table and the need for new LMS software with scheduling function.

Now let's summarize the information about major open-source systems in the **Table 1**.

Table 1.

LMS comparison

	MOODLE	Claroline	Dokeos	ATutor	ILIAS
SCORM	yes	yes	yes	yes	yes
IMS	yes	yes	yes	yes	no
Application language	PHP	PHP,JAVA, React Symfony	PHP	PHP	PHP
License	GNU/GPL	GNU/GPL	GNU/GPL	GNU/GPL	GNU/GPL
Multilingualism	> 54	36	38	> 50	43
DBMS	MySQL	MySQL	MySQL	MySQL	MySQL
Knowledge testing system	Tests, tasks, seminars	Tests, exercises	Tests	Tests	Tests
Mobile app	yes	yes	yes	no	
Analytics and tracking	yes	yes			
Scheduling / Schedule	no	no	no	no	no

So, we can conclude, that different systems have different drawbacks but no one system provides the Scheduling functions which are required from the schools and universities very much.

So, we developed the new LMS software with the scheduling function (will be described in separate work).

The main modules of the developed system are:

- scheduler,
- schedule viewer for different roles: teacher, class timetable, classroom load,
- change management support subsystem,
- API for integration with external content management system (LMS),
- API for data exchange (inputs, outputs).

Hence, the module for the schedule could be also integrated into other LMSes.

At **Fig. 3** – **Fig. 8** one can see the examples of the interface of the new proposed LMS with the scheduling functions.

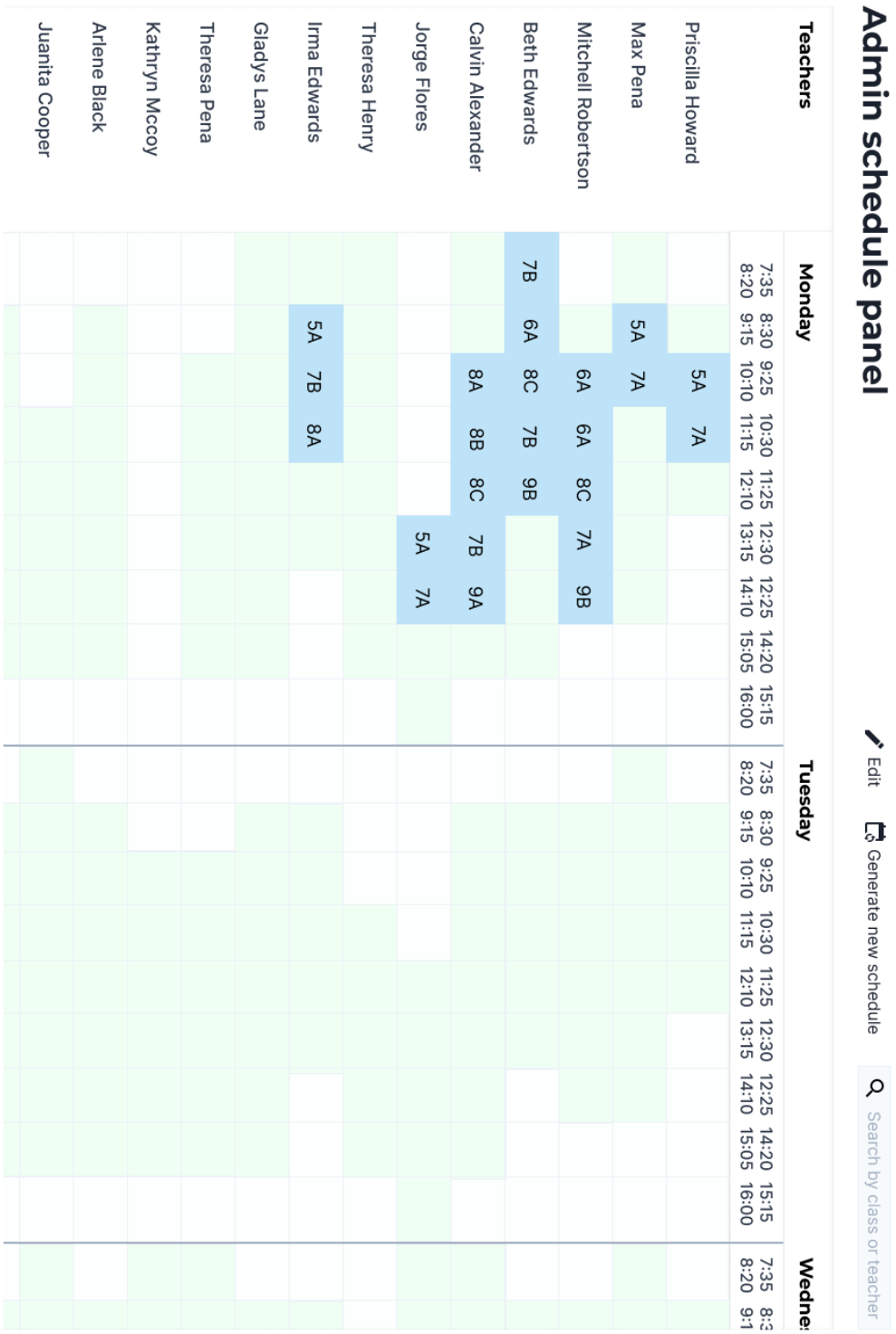

Fig. 3. Schedule example (administrator's view).

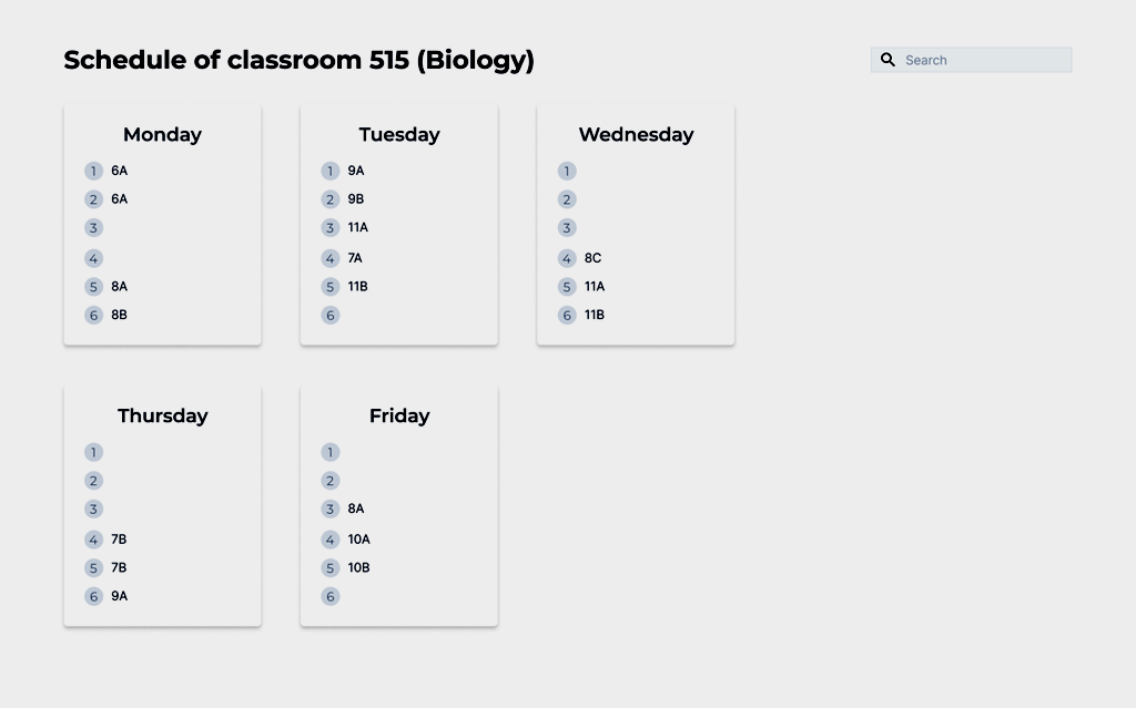

Fig. 4. Schedule view by rooms.

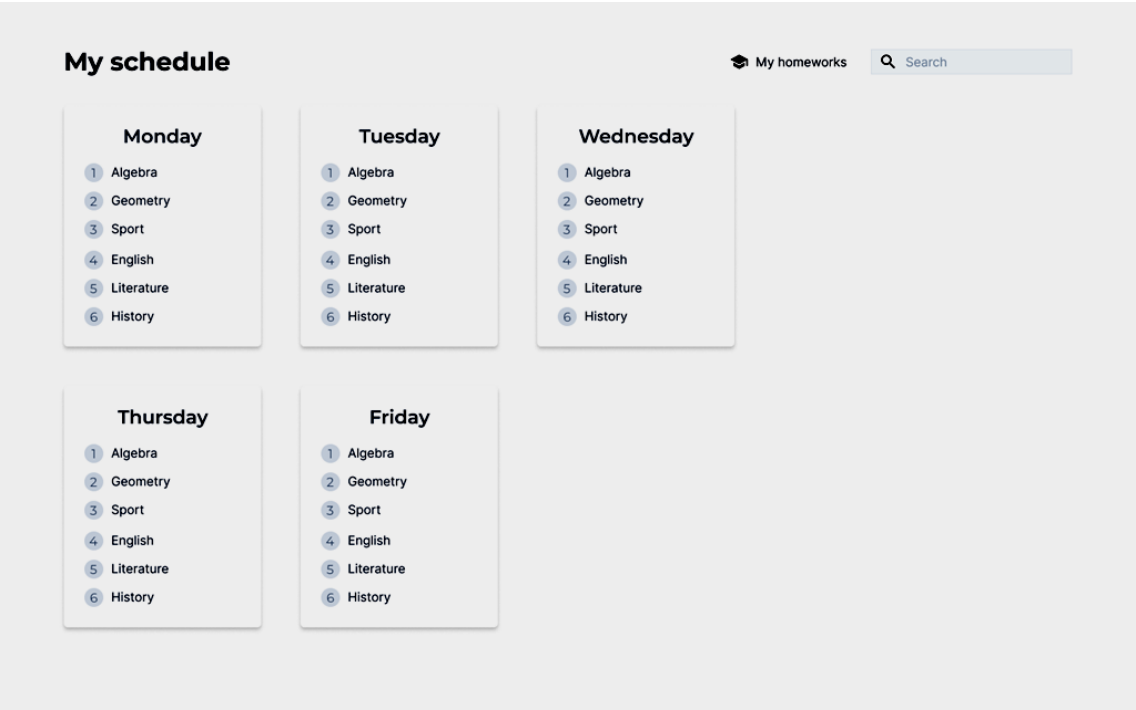

Fig. 5. Scheduler view (weekly, for the groups).

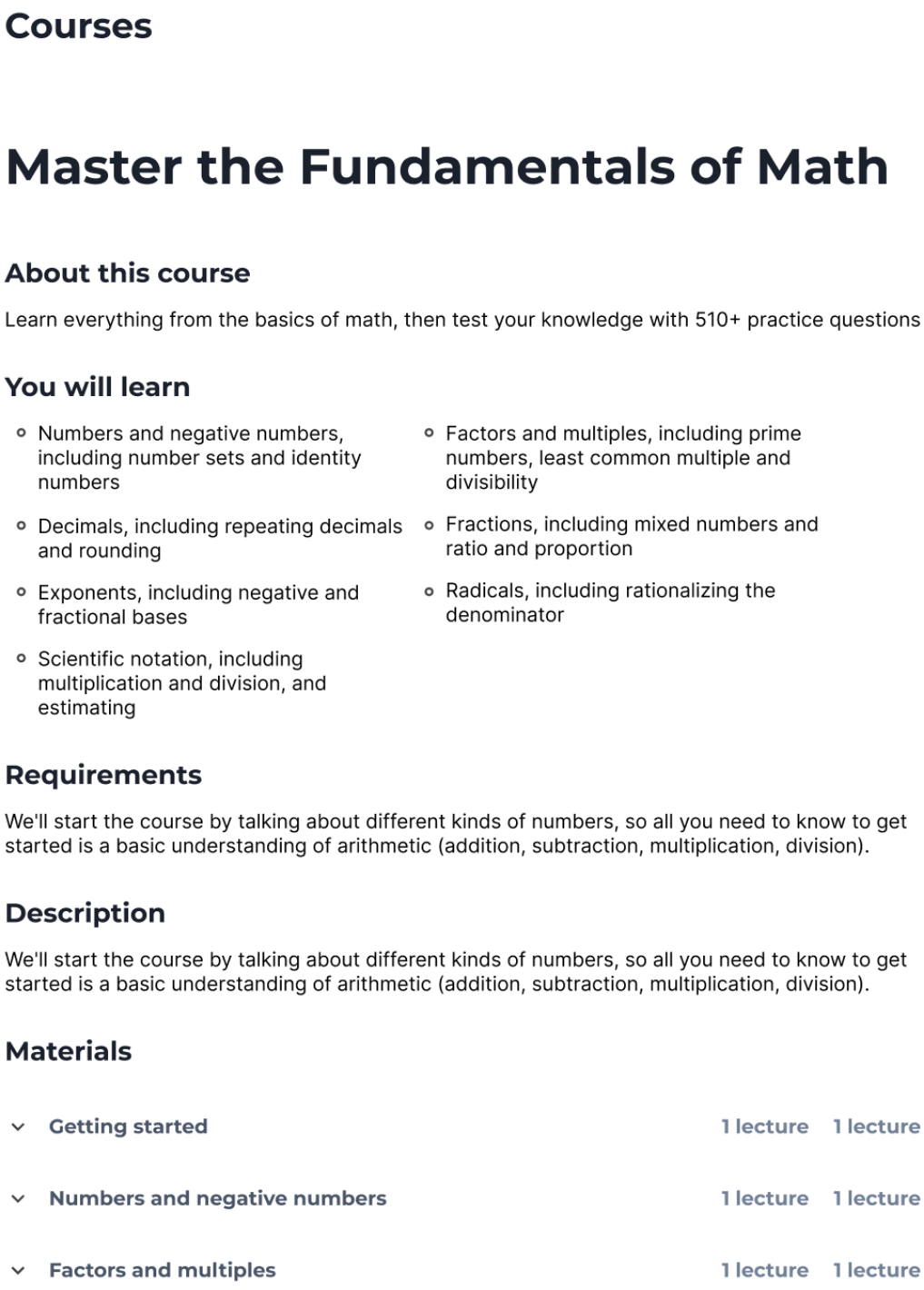

Fig. 6. Course syllabus example.

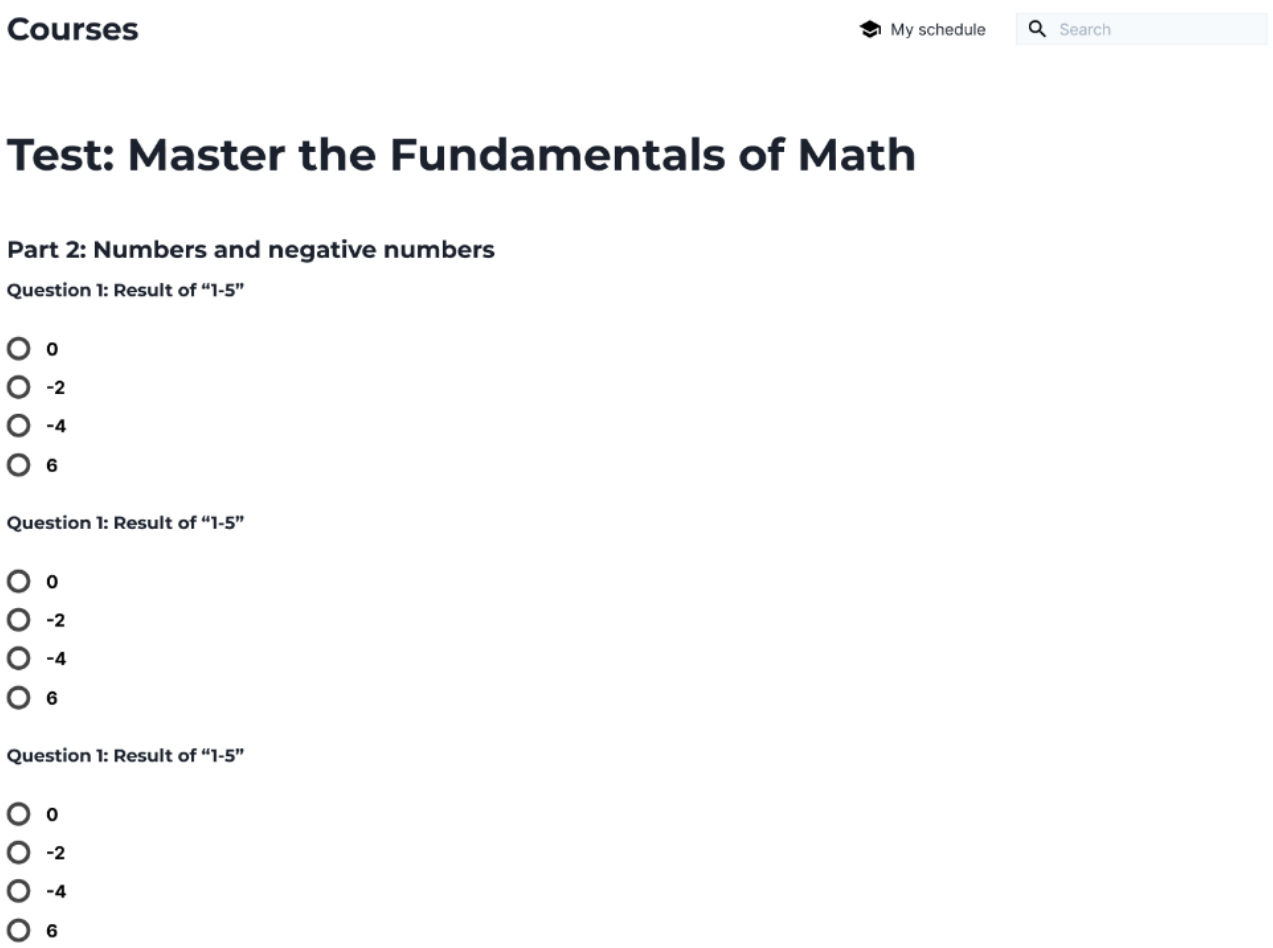

Fig. 7. Course test example view.

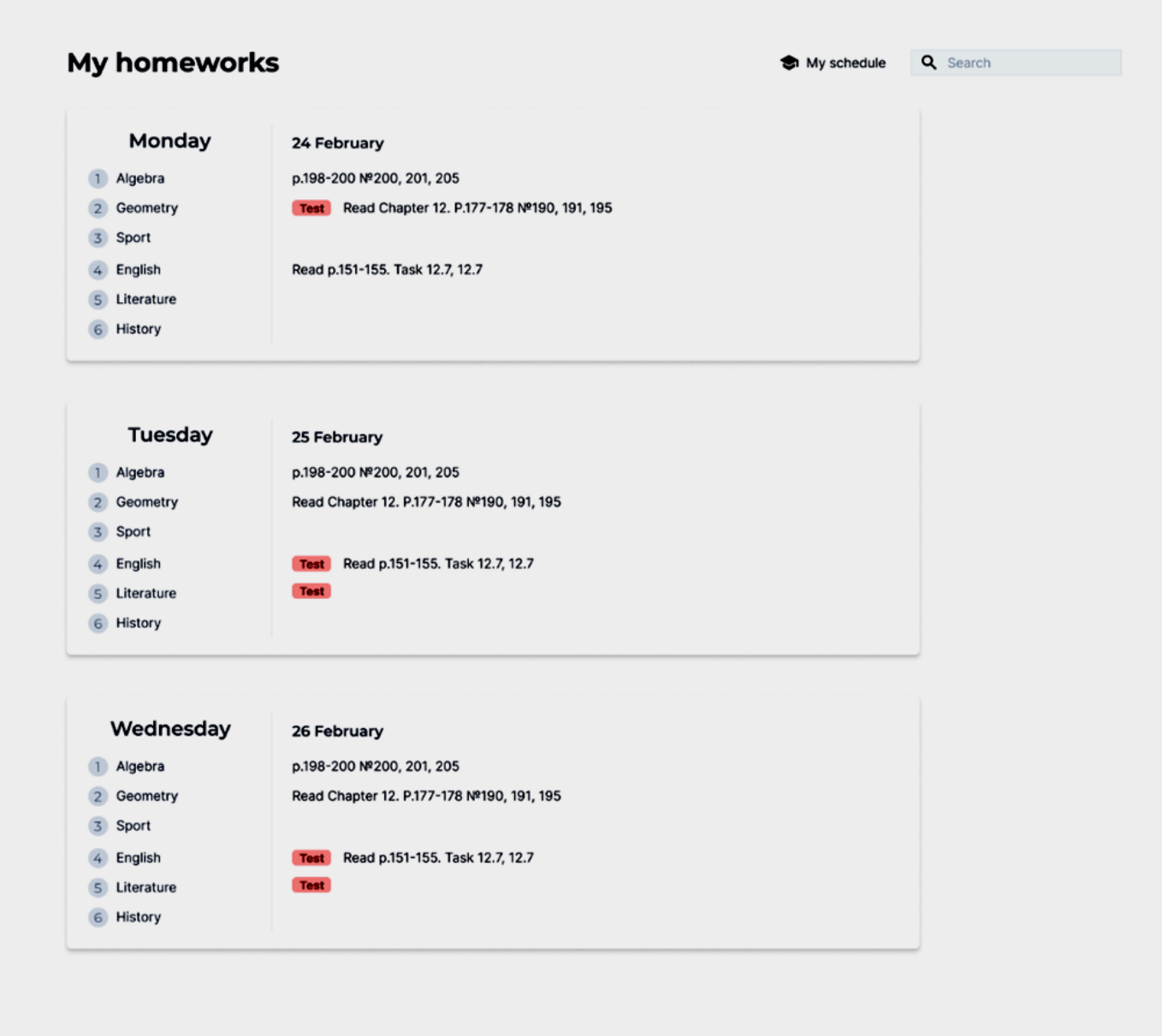

Fig. 8. Homework including scheduled tests during courses studying.

The details of this LMS will be featured in a separate paper.

Conclusion

We examined the most widely used Learning Management Systems [LTSC, AICC, IMS, ADL SCORM, ADL, MOODLE, Claroline, Dokeos, ATutor, ILIAS, SAKAI, LAMS, OLAT, OpenACS, LRN, COSE, LON-CAPA, ELEDGE, Colloquia, OpenLMS, Manhattan, DodeboLMS, Acollab], and we conducted the

comparative analysis and summarized the results in the appropriate table. Then we concluded that the scheduling functionality is omitted in all the systems, and we shed some light to the LMS developed to cope this lack. Also, we showed the pictures of the developed system, yet the system itself as well as the scheduling algorithm and the approach applied are the subject of a separate paper.

To summarize the comparison done here, main disadvantages of many systems are:

- absence in many systems of the Ukrainian higher education specifics of the organization of the educational process, that is, the document circulation between the management of the university, the deans of faculties, departments,

- lack of support for the Ukrainian language,

- inability to schedule classes.

The scheduling task is significant as it takes much time for manual work and has substantial practical importance. So, we are evaluating the results by experiments.

Unfortunately, the developers are not very concerned about the lack of timetable, although this will give a significant impetus to improve the organization of full-time as well as distant learning. Here are some benefits:

- it is convenient for the teacher to draw up a syllabus,

- the teacher can plan the lesson in advance (indicate instructional resources, methods, tasks) without spending time during the lesson,

- curriculum development would no longer take much time for the teacher,

- an automatic schedule would allow to import the curriculum of your colleagues at one click.

- gives the administration of the educational institution the possibility of convenient management and effective control.

In the future, it may be necessary to switch to another system, but most importantly, the skills of working with such systems will remain, that is, the infrastructure for supporting such systems will be created. And if the systems meet the standards, then the data will not be difficult to transfer.

Now we can conclude that we have 3 positive feedbacks from the schools and universities implemented our developed and proposed solution, so we do the features required development and also going to do the detailed poll of users of the system to analyze user experience in numbers.

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