Study of the student progress monitoring system of a university department for a distance learning system based on a Web portal and for OLAP samples using to automate analysis

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Abstract. Web-portal of ATIS department performs interaction of teacher with student to realize the educational process. However, in order to meet the standards of the main educational programs of the third plus generation, it is necessary to implement the tests on the Web portal within the training sessions in the disciplines of the curriculum. An OLAP progress cube should be developed to increase the information content of process participants. This OLAP cube will make it possible to present more clearly the student progress data needed for analysis. The information provided will help to identify the least quality in terms of educational progress and attendance of sites in the learning process. Thus, the OLAP-cube will allow to quickly process information with the possibility to build reports in different sections, to analyze the obtained data, to monitor the student progress.

1. Definition of analysis tasks
The effectiveness of the educational process is characterized by the quality of joint work of faculty and students of the university. Objective knowledge of students can only be obtained through systematic, properly time-distributed supervision of the teaching process by faculty.

The University assesses the quality of educational programs via the work monitoring of academic progress, intermediate certification of students and final certification of graduates.

Learning process control should be seen as a leading tool in the management of the educational process. It should be aimed to an objective and systematic analysis of the study and learning of educational material by students according to the requirements set out in the State educational standards, curricula and programmes of disciplines, and contribute to the improvement of the teaching level and the organization of educational works.

Regular analysis of students 'academic progress allows not only to record the degree of mastery of any discipline by a single student at the moment, but also to determine the adequacy of the teaching methodology to modern requirements, as well as to identify the trends in the development of the educational process.

Currently, the main paper on student attendance accounting is the student attendance accounting journal, which is a group one and is filled by group leaders and teachers. The teacher checks the presence of students in all types of classes, signs after each class "Group Journal" and gives to the
chief, who then gives up for check to the deanate, as well as the teacher enters this data into the Web-portal.

The main document to record the results of the current certification of students is the “Journal of accounting for students passing laboratory, computational and graphic and control works, course projects (works), as well as other types of compulsory classes”, which is filled in by teachers on the Web portal.

The work accounting of educational activities is carried out by teachers of departments, who are assigned for the curriculum disciplines, through grading, as well as keeping records of visits to all types of compulsory classes [1].

Intermediate certification of students includes passing exams and tests, protecting course projects (works), protecting reports on practices provided for in the curriculum of the direction (specialty) of preparation. The main primary document for recording the results of intermediate certification of students is the examination and test records, which are also entered on the Web-portal.

Figure 1 shows the mimic diagram of the existing process of conducting student progress analysis.

![Mnemonic diagram of the existing student performance analysis](image)

**Figure 1.** Mnemonic diagram of the existing student performance analysis

An analysis of students’ academic progress is carried out at three levels: within the department; educational department; Deputy Director of Educational Work, accordingly, the monitoring of
students' implementation of the curriculum is carried out by teachers, employees of ED and Deputy Director of EW.

Each teacher receives from the methodist of the department a "Journal of registration of students laboratory, calculation - graphic, control works, course projects, as well as other types of mandatory tasks," in which they systematize the results of students performing all types of current tasks and summarize the results of current academic progress, solving the issue of admission of students to examinations or quiz in the corresponding discipline. The availability of such data allows teachers to identify the lag of students and strengthen individual work with them, and it is reasonable to carry out certification of students "knowledge.

Examinations and quiz are the main forms of study process control. The main primary document for the accounting of the results of the intermediate certification of students is the examination and credit sheets.

Academic records, as well as forms of minutes of quiz and examinations of the ED are transmitted to the department. On the end of examination the examination sheet is given in ED, and the academic record - prior to the examinations personally the teacher. The teacher can also carry out an analysis of students' academic progress based on the results of the examination session, identifying the number of "excellent," horists "and students" debtors. "

Examination and academic records filled in by teachers are analyzed by the staff of the educational department in order to present the certification results by groups, courses, faculty as a whole and to draw up lists, not certified students and analyze the reasons for their lag. The results of the academic progress on the branch are transferred to the corresponding service of the university for analysis. On the basis of the results of the analysis of academic progress on the branch, the final results of educational progress on the university as a whole are presented, which are then transmitted both to the employees of the educational part and to the head of the department (as a rule, within the framework of the Council meeting) [2].

Results of academic progress analysis are discussed at meetings of departments, Councils. As a result of the discussions, measures are being developed to further improve the educational process and to improve the student training quality. The proposals to improve the training process are then prepared for consideration by the Deputy Director of educational work and in the educational department.

The most important functions directly affecting the student progress analysis are:

- filling of the Registration Journal of Students Laboratory, Calculation-Graphic and Control Works, Exchange Rate Projects, and as a result;
- admission to pass examination;
- filling of examination reports and protocols.

The department also has an electronic version of the student progress journal, realized as a subsystem "Progress Accounting" as a part of the department’s web portal. This subsystem is at the testing stage. The academic journal is available in the official portal of the ATIS department. The electronic version of the journal contains all the necessary fields to fill out (date of recording, discipline, student, type of control and evaluation). Each teacher can view the list of students by selecting a group of interest from the list. A sorting by students, laboratory work is also provided. Additionally, you can include a filter for the student group in the list. An existing gradebook is available to every teacher. One of the main problems is the data presentation inconvenient for an analysis. It is very difficult for teacher to keep track of students, to identify successful and unsuccessful students in the group, and as a result, a lot of time is spent on performing these operations. [3]

Considering all of the above, the existing process optimization should be determined as a minimizing of the time spent on the student progress analysis.
Elimination of the above disadvantages is possible by creating an OLAP-cube for academic progress, which will allow to display information in a more visual form, to use different detail levels and to analyze the information that is of interest to the user.

2. Justification of the need to improve the processes, structure or individual components of the study object
The main principle of the organization of the educational process quality control is the complex application of various types of control, distributed by time (education period) and by the disciplines studied. The university assesses the quality of educational programs development by performing the work control of academic progress, intermediate certification of students and final certification of graduates.

At the moment, the process of conducting academic progress analysis is regulated by the Regulation on Conducting Current Monitoring of Academic Progress and Intermediate Certification of Students and the Charter of the UGNTU.

In order to take into account the academic progress of students, teachers analyze the Journal of Registration of Students Laboratory, Calculation-Graphic and Control Works, Course Projects, etc., summarize the results after the examination session, analyzing the credit and examination statements, as well as student attendance.

At the moment, there is an electronic version of the "Journal of Academic Progress" of students, realized in the form of a subsystem "Accounting for Academic Progress" within the department Web-portal. The journal is available to each instructor and contains all the necessary fields to fill. The teachers can also complete and print electronic versions of protocol forms and examinations.

During the study of the process, it was found that it was difficult to analyze the progress of teachers. The data recorded in the electronic version of the "Journal of Academic Progress" has an form uncomfortable for analysis. In addition, each teacher can see only a part of the magazine with disciplines he teaches. In this connection, the problems arise in those personal who teaches one discipline, but carry out different types of control (for example, one gives lectures, the other takes courses). Thus, this process is very costly in terms of the amount of time devoted to progress analysis, and teachers are forced to transmit information to each other either in paper or verbal form.

In addition, the requirements of the third plus generation standards require the introduction of testing as a type of student progress control. It is proposed to implement the Moodle Learning Management System to form the tests, conduct the test itself and evaluate the results.

It should be developed an achievement OLAP cube which will allow:
- to obtain the complete and reliable data;
- to view the student progress data in a convenient, visual form, which will reduce the analysis time spent by a teacher;
- to analyze academic progress, both in detail - by type of control (results of testing, progress of railway works, progress of practical exercises, course projects (works), results of quiz and examinations, etc.), and in total form - by group of control types, etc.;
- to store the analysis results reliably;
- to improve the quality of knowledge assessment.

The expected effect of the system will include:
- the temporary effect obtained by reducing the time required to test control, as well as by controlling the acquisition of educational material by students, both in the current period and in the semester and annual period;
- a rationalization effect obtained by automating data processing;
- an effect of completeness, reliability and accuracy of automated data processing;
- an adaptive effect, ability of the system to adapt to changing conditions, possibility of system expansion and expansion.

Thus, the effectiveness of the proposed intelligent system, integrated with the Web portal and distance learning system Moodle, is formed not only by saving time for knowledge testing, but also is
designed to improve the quality of student control and analysis using OLAP sampling in terms of information support for teachers.

3. Identification of resources and constraints on the management system development

As resources to develop an IS, it is possible to highlight the following restrictions on technical and program tools, for financial resources, terms, experience of computer equipment operation, degree of user readiness:

Limitations on software tools: the implemented information system should be compatible with the Web portal of the ATIS department. A portal is an information system that provides to users a single, authorized, personalized access to the organization ’s internal and external information resources and applications. It is a single point of entry for users, a tool of information access, viewing and searching for content, an environment for integrating heterogeneous applications, an environment for interaction and collaboration. The web portal already exists at the ATIS department and is successfully functioning, including a number of subsystems (subsystem for maintaining the schedule of classes, placement of educational materials, storage of documentation, accounting for the load of teachers, rating). It is also proposed to use the results of the tests obtained in the Moodle Learning Management System to form the Progress Accounting subsystem.

According to the results of the survey of existing systems of education management (Moodle, IILAS, aTutor, JoomlaLMS, etc.) [4, 5], it is proposed to use the free Moodle system of education management.

Moodle is a software product that allows you to create courses and websites based on the Internet. Moodle is distributed free as open source software (OpenSource) under the GNU Public License (rus).

Moodle is written in PHP using SQL database (MySQL, PostgreSQL, Microsoft SQL Server, etc.). Moodle meets SCORM [6].

It runs on Windows or Mac operating systems and many varieties of Linux (e.g. RedHat or Debian GNU). The word Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment (Modular Object-Oriented Dynamic Learning Environment).

Moodle has been translated into dozens of languages, including Russian and is used in almost 50,000 organizations from more than 200 countries. More than 400 installations have been registered in the Russian Federation. The number of Moodle users in some installations reaches 40,000 people.

The system has all the necessary documentation and good user support, which can be obtained from printed publications, forums of official resource and community of developers, which allows to create additional modules for expansion of Moodle functions [4].

Moodle modular architecture allows to connect the following existing module types: course elements, administrator reports, job types, authentication plugins, blocks, course formats, course reports, database fields, course subscription plugins, filters, assessment reports, rating export formats, rating import formats, portfolio, test question types, test import/export formats, test reports, file stores, resource types, search plugins.

The web portal has a single database developed in the MySQL environment, the site itself is written using PHP language intended to write web pages. It would be useful to include the Achievement OLAP Cube in this subsystem. An OLAP cube can be built on a Microsoft Office Excel that can act as a development environment because it contains the standard components required to create and test a system.

- restrictions on financial resources: due to temporary inability to finance the project, the information system should be implemented using free software products;
- limitations on the degree of user readiness and experience of computer equipment operation: it is necessary to take into account the fact that not all teachers are advanced users of computers due to certain reasons or the level of knowledge of foreign languages allows to work only in Russian, so the implemented IS should have a simple and friendly Russian-language interface.
4. Setting of research goals and objectives to improve the management object
In the previous sections, the main disadvantages of the current student progress analysis were highlighted and the main tasks of improving this process were identified.

Purpose of work: development of an intellectual system to manage the educational process of an university department based on a WEB portal using OLAP samples.

To achieve the goals above, it is required to solve the following tasks:
- to identify the department’s business processes and explore the possibility of testing using the Web portal;
- to implement the Moodle distance learning system on the basis of the Web portal, to develop a testing system for students of the department as an implementation of the department's business processes;
- to develop a progress analysis system using OLAP samples;
- to create a control loop of the educational process of the university department.

Research methods: methods of system analysis, system modeling SADT / IDEF, theory of automated control systems, production organization and management [7].

Automation of the students' knowledge assessing will reduce the labor input of this task and will increase a labor productivity. Also, the implementation of such a system will facilitate the analysis progress both on the part of teachers, and from educational staff what will improve the quality of decisions.

Using an Achievement OLAP cube will allow to [8]:
- quickly analyze data in various slices and at any depth of detail;
- quickly generate reporting forms;
- timely receive the required data;
- maintain data integrity;
- rationally distribute the time of the department staff;
- automate routine operations.

Within the framework of the single information space of the department it is proposed to realize the academic achievement OLAP-cube on the basis of the Web-portal of the yield intelligent system of the department. At the same time, it is also proposed to implement a testing system (based on the Moodle education management system) integrated into the Web portal. And along the OLAP-technologies to keep all required statistics of examinations, quiz, to form in electronic form and to analyze the register of laboratory, calculation-graphic and control works, course projects (works), production (educational) practices, as well as other types of mandatory classes by students. To organize this process, the main document is the curriculum of the specialty and the work programs of the corresponding disciplines, which also influence the management impact on all business processes of the department [3]. The proposed system will allow, first, the teacher to form tests, second, to monitor the current indicators of student knowledge in a certain discipline, third, to create an archive of semester indicators of student knowledge in semester disciplines. By creating criteria for assessing student knowledge (benchmark), taking into account the requirements of aggregated progress indicators for Federal state educational standard disciplines cycles obtained in the form of OLAP samples, it is possible to adjust the educational process for students. And thus it is possible to adjust the objectives of the management of the educational process of the specialty, taking into account the impact of the ISO 9000 standard, which takes into account:
- specialty objectives contained in the state educational standard;
- the objectives of the department in the charter of the university;
- the objectives of the university as laid down in the Quality Policy and in the Quality objectives.

The proposed system of management of the educational process of the department of the university implements, first, the requirements of GEF of the third plus generation, second, the educational technology, which meets modern requirements in accordance with ISO 9000 series standards, which
will positively affect the quality of management of the educational process of the department as a whole.

5. **Define how to improve the processes, structure, or individual components of a study object**

Analysis of existing techniques revealed an amount of disadvantages that do not allow a rational management of the student progress analysis. It includes:

- inconvenient presentation of data;
- teachers in charge of one discipline (for example, one teacher lectures, the other takes laboratory work) do not have a complete clear vision of the situation and a single mechanism for accounting, monitoring and analysis. They have to transmit information orally and in paper to each other;
- statistics cannot be analyzed over time (comparison with previous years is difficult);
- insufficient and late monitoring of student progress;
- too much time due to poor automation;
- it is difficult to analyze statistics in general by department, by specialties.

Therefore, in order to overcome the above disadvantages, it is necessary to automate the analysis of the student knowledge assessment by developing an OLAP cube of academic achievement.

The results of the development will need to be placed on the Web portal of the department in order to provide fast access (through the Internet) to the OLAP-cube of academic achievement, both for teachers of the department and students, with the possibility to analyze the academic progress of students in various sections.

OLAP (online analytical processing) is a technology for a rapid information processing, which includes a dynamic report building in different slices and data analysis, which successfully allows to use OLAP to make decisions in all levels of organization management based on multidimensional data presentation. OLAP technologies are based on multidimensional information presentation. The user obtains a natural, intuitive data model by organizing it as OLAP cubes. During the information analysis the user can "cut" the cube in different directions, obtain the summary or more detailed information and perform other manipulations that he or she will need during the analysis process.

This development will make it possible to organize the process of the student knowledge assessing at the modern level and to provide a substantial information support to the process participants.

Figure 2 shows the mnemonic diagram of the proposed process of an student progress analysis.

6. **LS mathematical model**

As part of this study, a mathematical model is to be developed.

A mathematical model is a system of mathematical relations (formulas), equations, inequalities, etc., reflecting the essential properties of a designed information object.

The theory of sets was chosen as a mathematical model, allowing to describe requests to OLAP-cube for students' academic progress analysis.

The theory of sets studies multiple objects, i.e. a mathematical object is represented as a "set."

The mathematical model of data multidimensional representation is constructed using theory of sets and includes the following components:

A cube with data is noted as an amount of cells \( C(D,M) \), corresponding to the sets \( D,M \).

Allowing:

\[
D = \{d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8\} \quad \text{- multiple dimensions of the cube, where}
\]

- \( d_1 \) - Student;
- \( d_2 \) - Specialty;
- \( d_3 \) - Group;
- \( d_4 \) - Discipline;
- \( d_5 \) - Type of control;
$d_6$ - Test;
$d_7$ - Teacher;
$d_8$ - Record date;
$M_{d_j} = \{m_1, m_2, m_3, \ldots m_n\}$ - the set of dimension labels, where $n$ is the number of records in the entity (dimension).

**Figure 2.** Mnemonic diagram of the proposed process of student progress analysis.

Each cell of the cube $C(D,M)$ corresponds to the only possible set of label measurements. The cell can be empty (no data) or contain the value of the indicator - measure. In our case, the measure will be an assessment.

$X_{M,d_{1:k}} = \{0, 1, 2, 3, 4, 5\}$, That is, the assessment can take the following values:

'0' - Absent
'1' - Didn’t pass
'2' - '5' - Assessment.

It will make the following dimensions:
D - {'discipline 1', 'discipline 2', '..., 'discipline N_1'};
G - {'group 1', 'group 2', '..., 'group N_g'};
K - {'type of control 1', 'type of control 2', '..., 'type of control of N_t'};
P - {'teacher 1', 'teacher 2', '..., 'teacher of N_t'};
DT - {'date 1', 'date 2', '..., 'date N_d'};
St - {'student 1', 'student 2', '..., 'student of N_s'};
N - {'lab/work number 1', 'lab/work number 2', '..., 'lab/work number N_l'};
S - {'specialty 1', 'specialty 2', '..., 'specialty N_s'}.

It should be noted that the cube will be very discharged, since it contains a large number of dimensions. The cube contains all the information necessary for progress accounting and contains 8 dimensions. Therefore, we get a cube of the following size:

Amount of cells = D * G * K * P * DT * St * N * S

When working with a cube, user can perform the following basic operations:

1) Operation "slice" - the choice is made, reducing the cube. The subset of a hypercube resulting from fixing the value of one or more dimensions is called a "slice". The operation of constructing a slice is carried out with the aim of obtaining the required subset of cells and cutting off the "unnecessary" values, by sequentially fixing the labels. A slice, as a rule, is a two-dimensional data array (table).

By fixing the label m \in M, corresponding to the dimension d \in D, user subsequently determines the region of the data hypercube that interests him.

The query may look like this:

How many people from the group BUS-16-31 were present for testing in the discipline "ASUP," which was carried out by teacher Charikov P.N.

\{X_{i1},...,i8 \neq 0 \text{ and } X_{i1},...,i8 \neq \text{null} : i_1 = \text{‘Discipline’}, i_2 = \text{‘Group’}, i_3 = \text{‘Lab work Number’}, i_4 = \text{‘Teacher’}, \forall i_5, \forall i_6, \forall i_7, \forall i_8\};

2) Operation "convolution" - in the process of analysis, the user can move from detailed to aggregated data within the hierarchy of one of the dimensions;

3) Operation "rotation" - changing the order of presentation (visualization) of measurements. Provides the ability to visualize data in the form most comfortable for their perception.

7. Conclusion

The article refers to the set of software and technical tools necessary to develop and to implement the information system, as well as the justification for the application of the progress data OLAP-cube with the presentation of the main working forms of the IS for the progress analysis.

The developed information control system will allow to effectively and qualitatively check the knowledge of students in the main disciplines. At the same time, the level of computer literacy of the student does not matter. The system is designed to enable teachers to improve the quality of students 'education. In addition to the knowledge control itself, the system can be used in the online mode during self-monitoring and as a simulator. Through the use of OLAP technologies, development should improve productivity in maintaining all necessary test statistics. OLAP sampling, will reduce the likelihood of errors by automating the procedure for assessing student knowledge.

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