

Internal Monitoring System of a Modern University

VLADIMIR M. STASYSHIN, KSENIA N. LYAX
Theoretical and Applied Computer Science Department
Novosibirsk State Technical University NETI
20 Prospekt K. Marksa, Novosibirsk, 630073
RUSSIA

Abstract: - The system of institutional research is a trend of the current stage of development of modern universities and is aimed at conducting research, the results of which would be useful to the university management in carrying out its current activities and developing strategic directions for development. However, the effectiveness of such a system largely depends on the fulfillment of a number of conditions. These are organizational, personnel, software and hardware and other aspects, on the implementation of which the efficiency of the system depends. The article attempts to analyze the goals, objectives and approaches to the organization of the system of institutional research of a modern university. The article describes the organizational principles, software and hardware platform for the development of an internal monitoring system and institutional research at the university. Examples of institutional research are given.

Key-Words: - Competencies, software and hardware platform, university institutional research, Data analysis

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1 Introduction

Institutional or internal research (IR) first appeared in the United States in the 1920s, in the second half of the last century it began to penetrate into universities and other educational institutions in the United States, and is now one of the trends in the development of management systems of modern universities in North America and Western Europe. Recently, the ideas of conducting institutional research are becoming more widespread in Russian universities. This article attempts to analyze the main features of the development of institutional research in universities at the present stage.

The internal monitoring system of the University aims to conduct research, the results of which would be useful to the university management in the implementation of its current activities and the development of strategic directions for development. The university's internal monitoring system ensures the implementation of monitoring projects, the collection, processing and analysis of educational data, the presentation and discussion of results, the communication of internal survey data to the university community, and interaction with the management of the university in the field of internal sociological research.

There are two classes of tasks solved in conducting institutional research: meeting the requirements for the university's reporting to the Ministry of Science and Higher Education and other

governmental bodies, and developing a modern university management system based on a comprehensive analysis of the processes taking place in the university for making effective and useful decisions. In recent years, there are several trends in the transformation of higher education: the internationalization and mass nature of higher education, the ever-increasing influence of education on the economic growth, expansion and consolidation of universities. As part of ongoing digitalization, the volume of relevant data for analysis as well as the attention to nonreactive data have increased dramatically. In this regard, building a system of institutional research becomes a key issue in enhancing the competitiveness of the university and improving the structure of the university and its business processes. The opportunity to present yourself favorably to external contractors allows you to get more financial resources from the state and business, make the university more attractive for applicants and improve the professional qualifications of the university's teaching staff. The capability to make decisions supported by concrete data in order to strengthen business processes and change the internal structure of the university is essential for university management. The solution of these problems is directly related to the research made on existing business processes and data analysis [1].

The overall objectives of the institutional research carried out at the university are the following: to implement the university's digital transformation strategy, to ensure data based management, to support strategic management, and to improve business processes based on the analysis of accumulated data. To achieve maximum efficiency and well-coordinated work of a modern university, the system of institutional research should be actively integrated into the overall system of university management. This can be achieved by incorporating the results of university internal monitoring in strategic planning, policy development, performance evaluation, and the effective use of financial resources.

An integral consequence of the trends observed in higher education is the attitude of universities towards internationalization. A kind of international academic labor market is being created, within which both students, teachers, and researchers circulate. Accordingly, there is a need to compare the performance of universities not on a national scale, but on an international scale. This shifts the focus of research, the consumer of the results obtained in the framework of research, now becomes not only the management of a particular university, but also anyone who wants to compare the results of this university with the results of other universities.

One of the problems that university researchers may face is the isolation of the results of the research carried out from the real practice of university management and development. IR research is of an applied nature, so the dissemination and discussion of their results in relation to the activities of the university is as important a stage as the collection and analysis of data. Of course, university administrators play an important role in the use of analytics, but the popularization and dissemination of results is becoming an important task of the university researchers and IR-centers themselves.

The audience of the research results is not only the heads of the university and its individual departments, but also the entire university and near-university community, represented by applicants and their parents, students, teachers, researchers, graduates, employers, etc.

The analysis of publications [2-6] allows us to identify the following tasks of the university's institutional research:

1. Data integration and management; monitoring the actions with data - tracking the chain of data origin and their transformation.
2. Ensuring the operational turnover of data for

external and internal use - processing all the incoming and outgoing data from the university, including the management of external reporting.

3. Management of corporate data storage for solving managerial and regular reporting tasks.
4. Development and adaptation of tools for data collection, analysis and quality control.
5. Business process research and data mining using modern methods.
6. Visualization and dissemination of research results in the university community.
7. Preparation of proposals for the use of promising digital services and their guidance support.
8. Monitoring the implementation of digital services and new data-driven business-models at the university.
9. Normative regulation of data handling.
10. Building relationships with external organizations for the purpose of data exchange, organizing the work with external information flows, data brokers, interaction with the administration and units of the university.

Below in section 2, based on the analysis of the experience of various universities, the requirements that must be met to ensure the effective operation of the institutional research system are described, in section 3, the requirements for the software and hardware platform are described, in section 4, examples of research are given.

2 Organizational Aspects of Building an Institutional Research System

The tasks of internal monitoring and institutional research at the university, as a rule, are assigned to IR-center (Institutional Research center).

To achieve maximum efficiency and well-coordinated work of the university, the staff of the department should act as a kind of change agents, whose activities are to be integrated into the overall management of the university.

In general, there are several significant features of the activities of IR-center's that can help make the functioning of the university more efficient and contribute to the achievement of its goals. The first of these features is offer of "the Fostering a Broad Organizational View" [2]. Being a fairly mobile division, the center for institutional research can quickly perform tasks related to the collection and analysis of various intra-university information in a

short time. Thus, it is largely due to the data and analysis carried out by the center for institutional research that the staff and management of the university understand the context in which the university operates. Of course, this statement is true only if the IR center occupies the correct place in the hierarchy of university departments, the results of its activities are actively popularized, discussed and used, and its representatives are involved in the discussion about the trajectory of the university and are privy to the details of the upcoming changes.

The next important feature of the IR-center's activity is "the Prompting Connections and Collaboration" [2]. The IR-center, by its specifics, does not focus on specific highly specialized tasks, the focus of its research is the entire life of the university as a whole. In addition to the fact that this leads to the flexibility of research tasks, it also contributes to the fact that two or more departments of the university may be interested in the results of specific research at the same time. It is not uncommon for different departments of the university to try to analyze and solve the same problem with their own resources. In such cases, the IR center can act as an intermediary, helping both to understand the mutual interest of the parties and the benefits of cooperation in finding a solution, and to develop a more precise focus of the problem, to determine its exact causes and ways to eliminate it.

The third effect of the IR-center's is to "Stimulating Organizational Learning" [2]. The university, as an organization consisting of many departments, each of which, to some extent, pursues its own interests, may lack a common view "from above", reflection on its own activities. The purpose of this reflection is to answer the question "is the university moving in the right direction"? Specialized IR research can be an indicator of whether the university's activities correspond to its stated values and mission. In the case of a positive result, the university can be considered functioning correctly. In the case of a negative result, it is possible to direct their activities in the right direction by identifying categories of persons who do not contribute to the achievement of the university's goals or who interpret them incorrectly.

Organizational aspects of building a system of institutional research at the university are based on modern requirements for internal monitoring.

Requirements for staff competencies:

- understanding the general context of the university's development and the specifics of its organizational features;
- ability to work with data;
- high level of IT training;

- ability to interpret and visualize data.

Basic functions at a university:

- external – meeting the reporting requests, providing the external consumers (the Ministry of Science and Higher Education and other governmental bodies) with the data on the university's activities;
- internal – providing the administration with the information necessary for making informed decisions in the framework of educational, scientific, financial and economic activities.

Prerequisites for the development of internal monitoring:

- mass nature of higher education;
- forming a new type of relations between the state and universities;
- increasing the economic autonomy of universities;
- increasing competition between universities;
- new approaches to the university management, the need for continuous improvement of business processes.

Specific features of the IR-center:

- the effectiveness of the IR-center largely depends on the place it occupies in the structure of the university;
- the IR-center is directly subordinated to the rector and/or the first vice-rectors.

Requirements for the activities of IR service employees:

- maintain horizontal interactions with the main services and departments of the university;
- actively involve the employees of other services and departments in the discussion of research and its results;
- take into account different interpretations of the data received;
- act as change agents;
- do not limit yourself to the position of "pure measurement", but make recommendations and proposals for improving business processes.

Focus on nonreactive data:

- information about the behavior of a person in a "natural" situation;
- the events are important, not the views on the events;
- large amount of data;
- implementation of the "data-driven research" model, when the data are collected not to fit the hypotheses, but the hypotheses "grow" from the collected data;
- recording even "minor" actions.

The use of corporate information systems for analytics:

- integration of data provided by various university systems to perform analytical research;
- close connection with the university's information system, learning management system (for example, DiSpace platform at Novosibirsk State Technical University), and financial planning systems.

The level and quality of the presentation of research data is very important in the activities of the IR center's. Over the past decade, infographics have become increasingly popular as a convenient and compact way to present research data. Infographics speed up and simplify the perception of information, as visualization allows you to cover data in a few minutes, which would take several hours to master in the form of text. Moreover, the infographic reflects the "dry residue", key information and conclusions that may be lost in the text. Infographics are becoming not only a means of presenting data, but also a tool for analyzing it, as modern infographic tools allow you to detect and display very complex relationships and trends.

Currently, there are a variety of programs and online tools for data visualization, such as Creately, Google Charts, and others, which are updated annually. Visual.ly, Vizualize.me, Tableau, PowerBI, and others. The availability of such tools makes infographics a popular way to present data among researchers.

3 Software and Hardware Platform of the Institutional Research System

Analyzing the features of internal monitoring systems in various universities, we can conclude that usually they are built on a cloud platform. Taking into account that significant amounts of personal data are stored in the institutional research system, the most correct solution is to use a private cloud. This increases the security of the system, but requires the involvement of qualified IT-specialists. The details of the implementation of the software and hardware platform may differ, but, in any case, the architecture of the cloud platform (Fig. 1) includes a network infrastructure, a data storage system and software for managing it, a virtualization cluster, client devices and software for remote access to virtual machines.

Taking into account that a very large number of employees participate in the work of the institutional research system, reliability and mobility

are the decisive factor in the software and hardware implementation. Due attention should be paid to these characteristics of the system. And this inevitably requires serious costs.

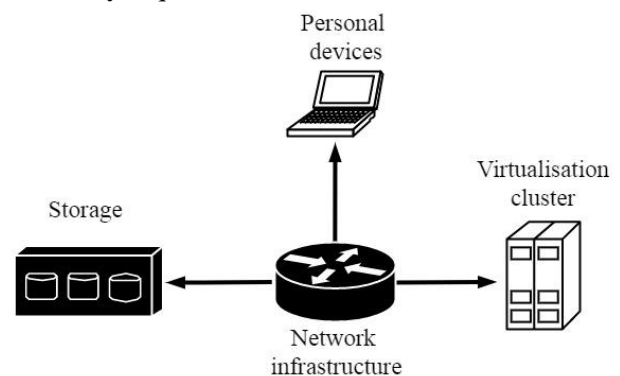


Fig. 1: Cloud platform architecture

To host virtual machines, you should use algorithms that provides:

- fault tolerance of the system by setting the minimum amount of free resources on the servers, depending on how many computing clusters we are willing to lose;
- ability to migrate machines in the process of their placement.

In the course of the functioning of system of institutional research, it is often necessary to develop additional software to solve the problems of the university. The Report Warehouse subsystem used for storage and delivery of reports is a means of communication between the university users and the system of institutional research. This subsystem ensures the receipt of requests for research, data collection or reports generation on the data stored in the university information system or other data sources. It also provides for the storage of generated reports and research using modern methods of data analysis (neural networks, classification methods, clustering, etc.). In addition, the Report Warehouse subsystem notifies the customer about the work done and distributes data about the research conducted in the university community.

4 Some Areas of Institutional Research

Below are some areas of institutional research at Novosibirsk State Technical University.

I. Formation and up-to-date maintenance of the electronic database of university performance indicators. The aim is to prepare a platform for the transition to data-driven university management.

The solution of the problem includes the following steps:

1. Building a model of interaction between departments in preparing reports, models of relationships between indicators, audit organizations, analysis and identification of mutual dependencies (impact analysis).
2. Construction of statistical models of interaction of indicators, predictive models, including those that take into account the degree of "confirmability" of values.
3. Identification of key indicators used in making management decisions.
4. Building management models "indicators – decision-making".

In the future, the developed platform should work out recommendations and record whether the recommendations were accepted, and when they were accepted.

The project owner is the Rector of the University.

II. Maintaining a digital profile of a student, forming a map of becoming a specialist. The goal is to form a comprehensive set of information about the student's academic, extracurricular, scientific and professional competencies in the student's personal account, using the objective means.

The project owner is the Vice-Rector for Academic Affairs. Faculties and departments are the participants concerned.

III. Development of a subsystem for visualizing the implementation of plans and projects. Dashboards.

The goal is to ensure that decision-makers can access meaningful information online.

The project owner is the Rector of the University.

IY. Educational data mining (EDM).

A platform for discussing methodologies for analyzing educational data is the Journal of Educational Data Mining (JEDM) [3].

An extensive analysis of the research in this area and the main tasks of the current decade contained in [4]. These are "transfer student model from learning system A to learning system B (portability)", "differentiating interventions and changing life (effectiveness)", "knowledge tracing beyond the scene (applicability)", and "general-purpose boredom detector (generalizability)". The author suggests that these research "will bring the field closer to achieving the full potential of using data for the benefit of students and transforming education for the better".

Now huge amounts of educational data have accumulated and stored in the universities' information systems. Educational data mining makes it possible to conduct comprehensive studies

of educational business processes and, indirectly, other business processes at the university [5-10]. The goal is to identify patterns and factors that affect the educational and other business processes of the university, adjust business processes in order to improve the quality of education.

Intelligent analysis of educational data is a field of Data Science. Intelligent analysis of educational data uses a wide range of mathematical methods. These are data mining and machine learning tools (clustering, classification, neural networks, correlation networks), methods of psychometrics and applied statistics (correlation, variance and regression analysis, factor analysis, component analysis, relationship analysis, time series analysis), visualization and computer modeling methods, and others (Fig. 2).

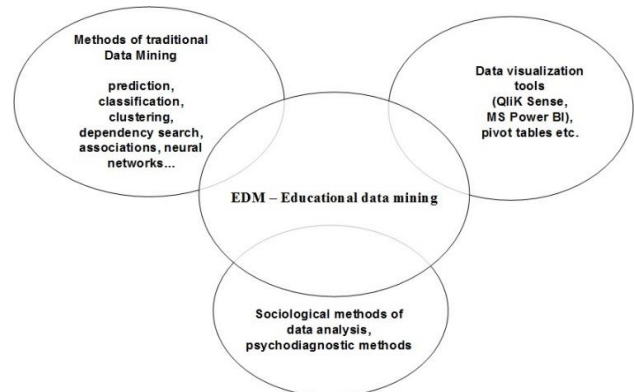


Fig. 2: Methods and tools of EDM

The project owner is the Vice-Rector for Academic Affairs. The participants concerned are faculties, the academic administration, Department of Education Strategy, deans' offices, teaching staff. The results of these studies are recommendations and suggestions to the university management on improving the learning process and improving the quality of education.

Some studies conducted in this area at Novosibirsk State Technical University list below.

1. Research on various principles underlying student group formation.

It is shown that the formation of a student group by including students only with a low Unified State Examination (USE) score leads to the degradation of the whole group. The creation of groups by including students only with a high USE score certainly guarantees both a higher percentage of successful graduates from these groups and a higher average score, but this is achieved at the expense of student expulsion from the groups with a low USE score. The uneven division of students into groups according to the USE score for the sake of teachers'

convenience should be recognized as a vicious practice that that leading to the loss of students.

2. Analysis of the degree of correlation between the grades for graduate qualification works and academic performance.

The graduate qualification work for a degree of Bachelor of Science is the final stage of undergraduate-level study, a kind of quintessence of a student's four-year work on educational program completion. In this regard, it is logical to assume that the level and quality of such works, and, consequently, their assessment should correlate with students' academic performance throughout the period of study. Certainly, one can give examples when a poorly trained student prepared and brilliantly defended an excellent graduate qualification work, highly assessed by both their supervisor and the Government Examination Commission, but this is most likely an exception. In this regard, a study was conducted to determine how the grades recommended by the supervisors of graduate qualification works and the ones received by the students after presenting these works orally correlate with their academic performance throughout the whole study period.

These studies have shown that a number of teachers tend to give too high marks for graduate qualification works. Similarly, it is possible to identify a group of teachers who are excessively strict compared to others in their assessment of graduate qualification works.

3. Institutional research on curriculum improvement.

The quality of education at the university largely depends on the level of curricula and contents of academic disciplines. Only state-of-the-art training programs can ensure the competitiveness of the university. An important tool to help improve the curricula is the graduate feedback system. This system, in particular, makes it possible to get information not only about the technologies the graduates own, but also about the technologies that are in demand and relevant in today's rapidly changing world. The analysis of this information allows us to make recommendations for adjusting the curricula.

Other examples of research in the field of educational data mining and recommendations for improving business processes at the university contained in [11]-[12]. They are

- analysis of the contingent of applicants and persons who entered the university for the period 2011-2020 in order to develop recommendations for improving the professional orientation of the university;

- the study of various models of the dependence of students' academic performance on the USE score and the reasons that give rise to them;
- analysis of variables-factors that affect the expulsion of students (the task of retaining students);
- analysis of the quality of educational resources prepared by university teachers in the system of effective university contract and etc.

5 Conclusion

The implementation of the university's digital transformation strategy, providing data-based management, supporting strategic management, improving business processes based on the analysis of accumulated data are the most important tasks of any university.

Building a system of institutional research is an important means of increasing the competitiveness of the university and improving the structure of the university and its business processes. However, the system of institutional research may be effective, or it may be ineffective. And it depends on how fully the requirements and conditions described by the authors in this paper are met.

The focus of the leading Russian universities on leadership in the world rankings, clearly expressed through participation in the state program for improving competitiveness 5-100, suggests that the need to form an internal analytics system similar to IR in foreign universities is becoming increasingly relevant. An increasing number of Russian universities are trying to build their own systems of institutional research. Methodological foundations are developing, and ideas about how such a system should be arranged are forming.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Vladimir M. Stasyshin - the author of the project, software and hardware architect, research conducting, data processing and analysis.

Ksenia N. Lyax - solving organizational issues, methodological guide, data collection and cleaning.

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