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A Graphical Language-Based Approach for Database Modeling in Higher Education Information Systems

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ABSTRACT

This study centers on the development and structuring of databases designed to facilitate information support within the sphere of higher education. The primary scientific objective is the construction of an innovative model for this purpose, employing a graphical language-based methodology for database modeling. The focus of this research is a singular higher education institution's information system, serving as a representative sample due to its complexity and socio-economic scope. The novelty of the research lies in the application of a graphical language approach to database modeling, which provides a fresh perspective in the field of educational information systems. The pivotal entities identified for inclusion in the database include problem-solving technology, design technology, and process control technology. The functions of this information support system encompass the provision of requested information, content generation, and additional support services. The study acknowledges its limitations, primarily its exclusive focus on a single educational institution's information system, which may not fully encapsulate the diversity of higher education systems. However, the institution was selected for its comprehensive and multifaceted nature, rendering it a suitable candidate for modeling and subsequent research. Future research endeavors should extend this modeling approach to a broader range of higher education institutions, thereby enhancing its applicability and potential for generalization.

1. INTRODUCTION

Informatization has emerged as a driving force in the transition to an information society, transforming traditional processes and shaping contemporary perceptions of education. The current belief is that educational institutions function more as access points in the utilization of information through software, rather than merely repositories of knowledge.

The advent of new information technologies has instigated significant alterations in the service systems. Traditional bibliographic activities have been replaced by novel forms of information search and storage. Modern libraries continually expand their service offerings, including the creation of electronic catalogs, formation of electronic databases, and the provision of information from electronic resources. This shift towards digital platforms emphasizes simplicity, convenience, and efficiency, marking a departure from traditional methods of accessing information.

Current activities prioritize the maintenance and promotion of library websites, the utilization of electronic remote-access resources in educational and research processes, and the development of online services based on document collections. In the era of pervasive information and computer technologies, websites are tasked with fulfilling essential functions such as providing information support and unlimited access to informational resources. Experts now view websites as tools that replicate the functions of physical organizations in the virtual space, offering additional capabilities to users.

The integration of traditional and electronic resources is instrumental in satisfying the information needs of users, facilitating the establishment of a new style for modern institutions. The research work focuses on a range of issues, all converging on a single goal-the high-quality, timely fulfillment of user information needs, and ensuring that the information resource aligns with these needs.

The current trajectory of information technology development emphasizes the creation and implementation of information systems. However, unchecked development of these systems can lead to substantial, and often unwarranted, strain on the hardware resources of the information system. This poses a significant problem for any institution, particularly those in the educational sector.

The process of creating a database for a university's educational and scientific environment is complex, encompassing scientific, technical, organizational, pedagogical, and socio-economic aspects. This process involves the formation and effective utilization of information resources to meet the information needs of both internal and external stakeholders in educational activities. This paper addresses the critical issue of creating databases for information support in the educational process.

2. LITERATURE REVIEW

2.1 Literature review

Numerous studies on information support for the management of the educational sphere prove the great complexity of this process [1, 2]. Due to the dynamism and sometimes unpredictability of various kinds of tasks and conditions that arise around the control object, the task arises of combining the best components of existing practical experience, searching for new approaches, and creating new technologies to support the management process, its control, and evaluation of results.

The integration of information systems can occur at the database level and any software level, depending on the architecture of the integrated systems [3, 4]. Data integration is implemented by a set of methods, architectural approaches, and software tools that provide consistent access and data delivery for the entire set of applications and processes available in an educational organization.

The introduction of information systems and educational organizations has its historical features [5, 6]. As noted in the literature, the introduction of a database occurs, as a rule, gradually, evolutionarily. It starts with individual units, then spread to most of the educational organization. In the course of implementation, technologies change, and the views of senior managers on certain aspects of informatization, on approaches to choosing software, may change. As a result, a typical educational informatization environment consists of several systems that were developed at different times by different developers on different platforms in accordance with the understanding of the processes that existed at that time. Such systems function as separate technological "islands", with separate, often incompatible, data models. On the islands of information systems, there are a large number of databases containing duplicate and non-standardized data.

For the successful functioning of a modern system, a special information environment is needed in which all participants in the educational process will interact harmoniously [7, 8]. A feature of the current functioning of information systems is its saturation with information flows that are diverse in content and volume, as well as the presence of a large number of users, different groups of which have unequal information needs and access rights to information resources. The educational process is associated with the generation, transformation, storage, and use of information resources of a large volume.

Recently preference has been given to the creation of systems for the functioning of the information educational and scientific environment of the university based on the adaptation of existing template solutions or the development of tools for their creation [9, 10]. The advantage of all approaches, except for the first one, is that they separate the information educational and scientific environment from the means of its creation, moreover, they have the properties of a tool that ensures the creation and functioning of the information educational and scientific environment of the university.

It is rightly noted that an important characteristic of the existence and change in the state of an information system is its life cycle [11, 12]. This concept can be interpreted as a set of stages that an information system goes through in its development from the moment a decision is made to start its creation to the moment when this system ceases to function. According to the life cycle of an information system, this is the entire period of the system's existence from the beginning of development to the end of its use and disposal.

Summarizing a general review of the literature, it should be noted that the topic we have chosen is complex and complex, given that the information support of the educational process is a relevant and important phenomenon today, given this, the formation of measures to improve it is an important and urgent issue.

2.2 Formed conclusions from the literature review

There are a sufficient number of software products on the IT market that allow automation of the educational process of the university. The quality indicators and ease of use of such control systems at different universities are not the same and depend on the experience of the developers and the technical requirements imposed on them. However, there are certain trends regarding both positive and negative features of the use of such systems [13].

However, the issues of modeling the process of forming databases for information support of the educational process remain insufficiently developed.

The structure of the article implies a review of the literature, methodology, presentation of the research results, their discussion, and conclusions.

3. METHODOLOGY

Modeling and optimization as methods play an invaluable role in modern science and education. The use of these methods creates unique opportunities for the development and optimization of the educational process, in addition, their use most often leads to the expansion of the information system, an increase in the efficiency of resource use and labor productivity, and also contributes to a significant improvement in the quality of information support. In this study, we will attempt to improve the information support of the Jagiellonian University. Thus, in this study, the data flow diagram (DFD) modeling method is used to develop a model of the database formation process.

Methodology - DFD - Data Flow Diagram - is a graphical or visual representation that uses a standardized set of symbols and notation to describe information provisioning operations through the movement and formation of databases. They are often elements of a formal methodology, such as a method for analyzing and designing structured systems. Superficially, DFDs may resemble flowcharts or the Unified Language (UML), but they are not intended to represent the details of program logic.

The classic DFD diagram consists of functional blocks representing the functions and operations of the described process, and lines with arrows that show the movement of

databases between these functions and operations. Function blocks are shown as a rectangle with rounded corners. In the middle of the rectangle, the name of the function or operation is indicated in the form of a verbal noun, for example, processing input documentation, agreeing on a draft contract, or planning. It is also allowed to use verbs in an indefinite form, for example, sign an order, issue a pass, or ship goods. The functional block is numbered in the upper right corner using the Latin letter "P" and the serial number in the diagram. Arrows show inputs and outputs to functional blocks, and how database information flows between jobs, repositories, and external entities. The output from one job must be the input to one or more other jobs. Inputs and outputs can be external and internal. Each arrow should have its own name, meaning the flow of data, and information. There are different graphical notations for representing DFD diagrams.

The data flow diagram is often used to identify processes and databases used in the course of their implementation, as well as to build a functional decomposition of the object under investigation (information system). However, this methodology does not allow showing those responsible for performing certain operations in the process and does not allow describing all possible ways of performing this process. Through a data diagram, only one implementation of the process is shown, and it is impossible to indicate cases where there are any deviations, as a result of which the implementation is slightly different.

In general, it is not correct to consider the information systems of the educational process in a generalized way. Should be specified. Thus, we will choose a specific information system of a specific educational institution. This will be the Jagiellonian University, where teams of the authors of the article work.

4. RESULTS OF RESEARCH

In this section, we presented the following results: the main problems of the information systems of the Jagiellonian University were systematized. In addition, models were formed for creating databases of information support for the educational process, as well as a model for performing the basic functions of information support for the educational process, which should significantly improve the information support of this educational institution.

In general, in the case of the information system of the educational process we have chosen, we have identified several characteristic problems (Figure 1).

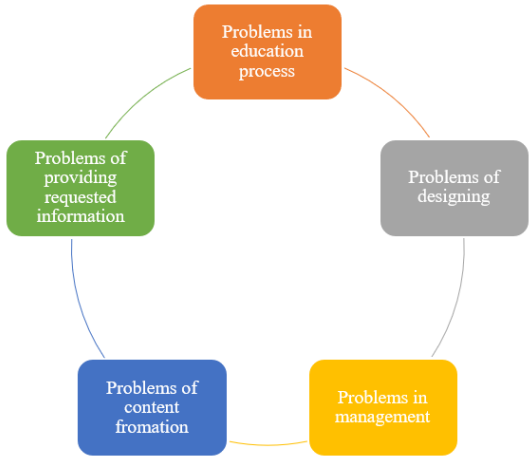

Figure 1. The main problems of the Jagiellonian University information system (Developed by the authors)

It is the problems of information support for the design process and problem-solving that should be taken into account when modeling.

To begin with, you should decide on the main purpose of modeling. In our case, such a goal will be reflected mathematically as P. The formation of databases for information support of the educational process. To do this, it is necessary to highlight the key processes for achieving it (Figure 2).

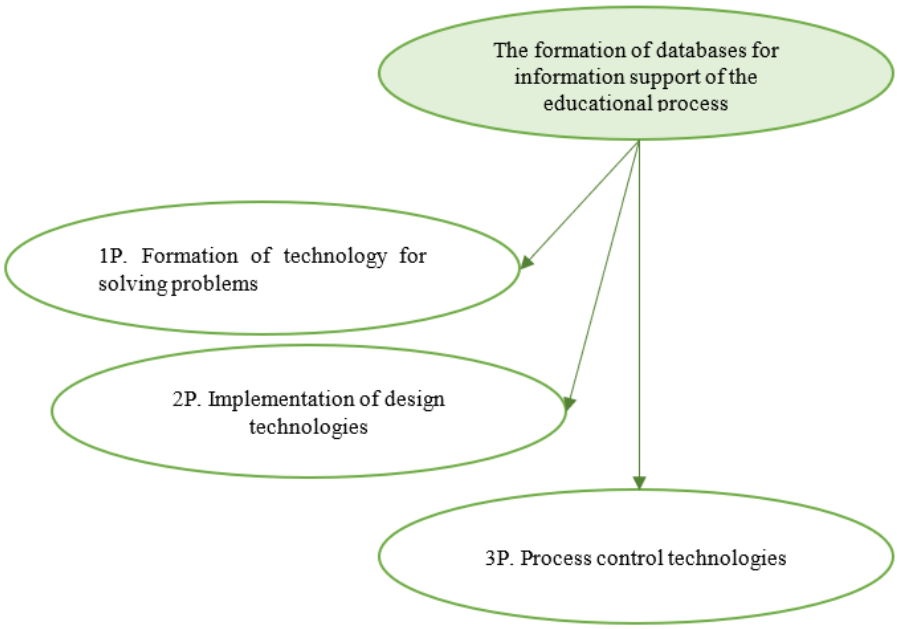

Figure 2. Processes of execution of the goal of modeling (Developed by the authors)

The result of modeling the use of a graphic language for the formation of databases for the educational process is shown in Figure 3.

1P. Formation of technology for solving problems. Information development for solving functional problems uses an information resource located on the bases of reference information and information on functional problems of the educational process. Traditionally, the information base of functional tasks is divided into databases of various tasks, to which integration tools are applied to create a single information environment.

2P. Implementation of design technologies. Project activities are organized on the basis of project management standards, which form the basis for interaction between project teams. At the same time, project management standards usually do not contain clear definitions of how certain actions must be performed, but only what must be done to effectively manage the project. The standard also contains a definition of the basic concepts, a list of specialists required to complete the project, and a description of the main design processes.

3P. Process control technologies. The task of creating a digital space should be separated from the functional tasks to be automated and should act as an independent backbone component of the digital educational process.

In addition, it is necessary to present a model for performing the main functions of information support for the educational process (Figure 4).

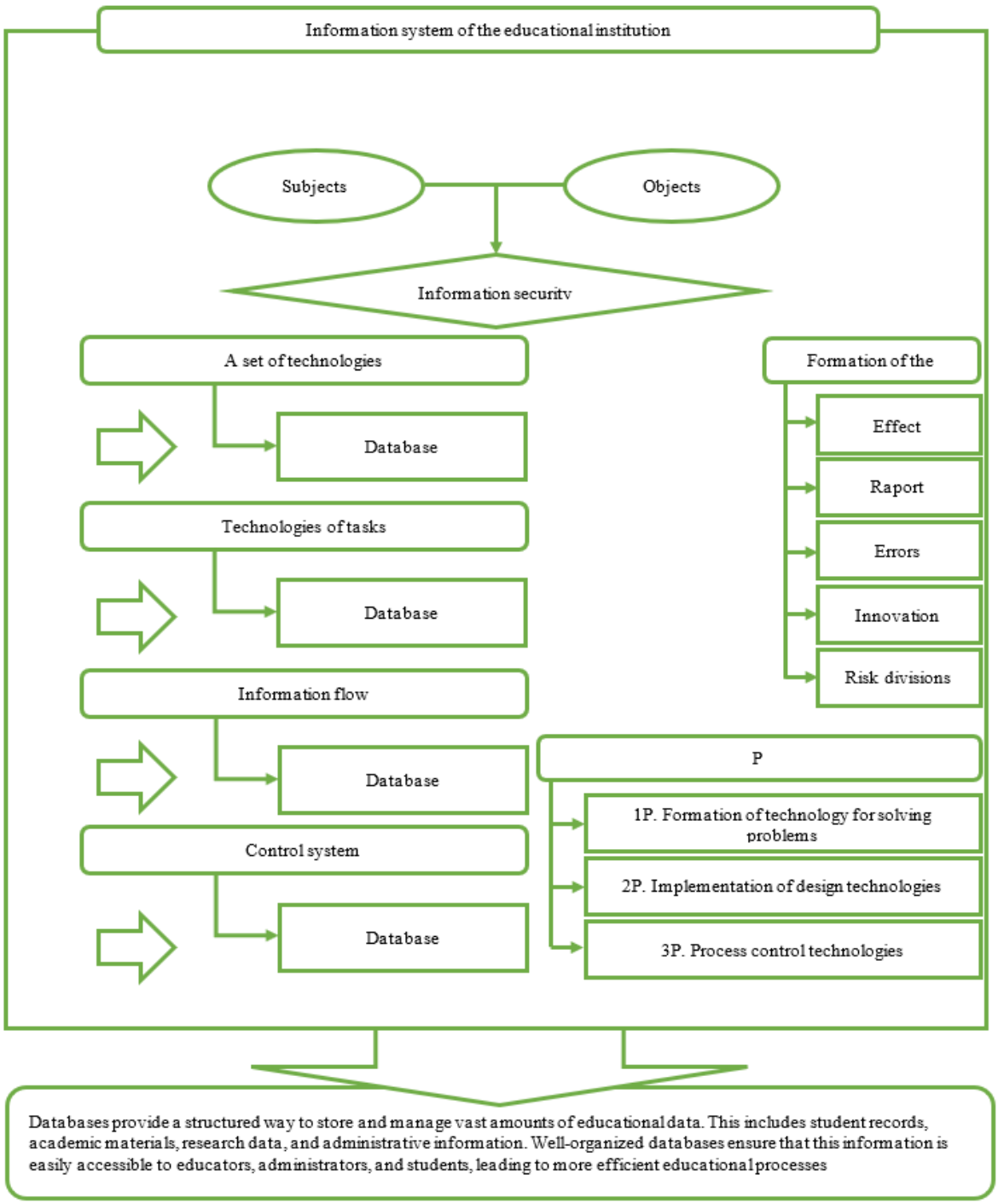

Figure 3. The result of modeling the use of a graphic language for the formation of databases for the educational process (Developed by the authors)

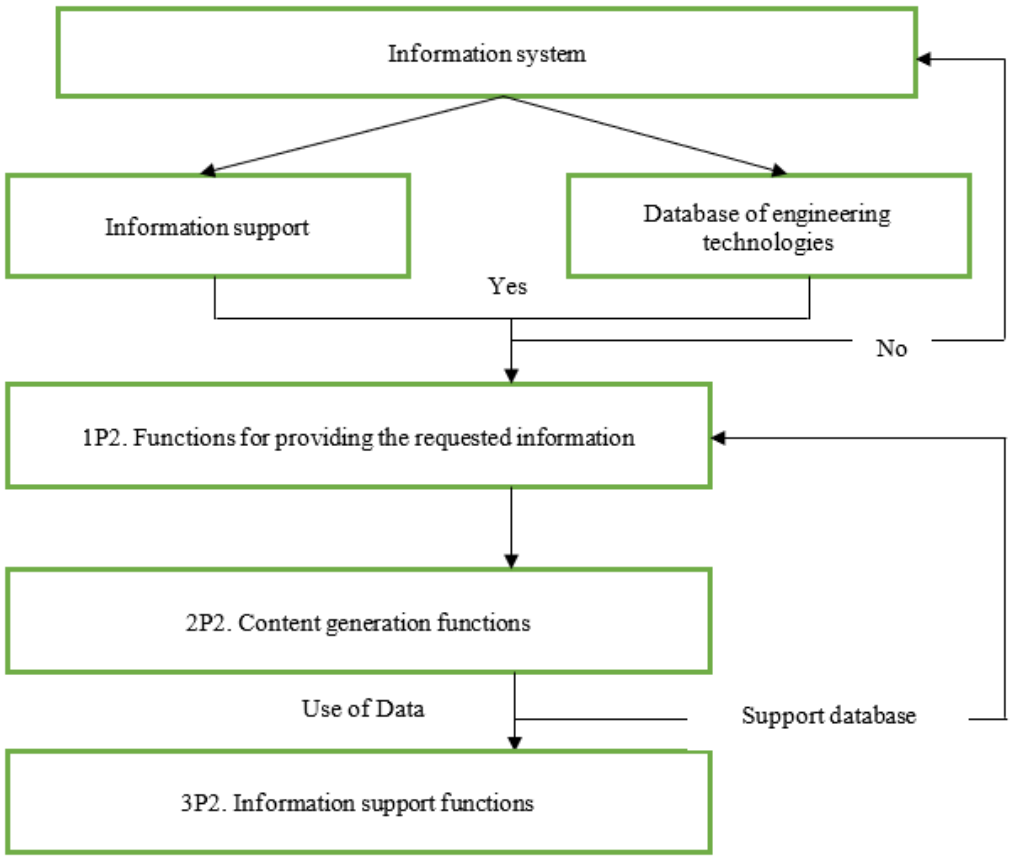

Figure 4. The model for performing the main functions of information support for the educational process (Developed by the authors)

1P2. Functions for providing the requested information. y. These functions select the requested information and transfer it to consumers. This information should also be in the regulatory reference base or the information base of functional tasks. But it is usually not in the form that the consumer needs. Therefore, it is necessary to develop additional tools for accessing these databases and presenting information in the required form.

2P2. Content generation functions. Their implementation is aimed at providing the necessary information not only to the employees of the educational institution but also to external consumers interested in the life of higher education. These functions select the necessary information from information bases, whether they are entered by employees and it is posted on websites. Traditionally, information is divided into two categories: received from information bases; introduced by employees (usually a special unit).

3P2. Information support functions. Functions of information support for the activities of an educational institution, which are components of information management systems. They provide the necessary information to the employees in the information management modes: electronic document management, control over the execution of instructions, digital archive of documents, and communications.

It is necessary to establish an appropriate periodization of how much time is needed to complete a particular process according to the constructed model (Table 1).

In general, for the information system of the educational process of Jagiellonian University, the implementation of the set processes at the appropriate time is inherent.

Table 1. The matrix of periodization of execution of model processes (Developed by the authors)

	1 Month	2 Months	3 Months	4 Months
1P	+	+		
2P		+	+	
3P			+	+
1P2		+	+	
2P2	+	+		
3P2			+	

5. DISCUSSIONS

When discussing the results of our own research [14, 15], it should be noted what should be compared with similar ones. As leading scientists note, work was carried out to solve such theoretical and practical problems as determining the content, direction, and volume of information flows, and methods of its collection, transmission, and processing. Based on the solution to the above problems, information flows were improved and the document flow associated with this in the management system, the information necessary for monitoring and control was determined. Research was carried out on information modeling of structures and processes in the educational environment.

As a result, other scientists [16, 17] note that education cannot remain aloof from global digitalization processes. Now the digitalization of education is imperative for reforming the educational industry, the main and primary task of the effective development of the information society. Moreover,

higher education is considered to be one of the largest industries and is well-positioned to reap significant benefits from digital transformation.

A different group of scientists [18-20] in their studies notes that the issue of informatization of education is considered more systematically - as a set of interrelated organizational, legal, socio-economic, educational and methodological, scientific, technical, production, and management processes aimed at meeting information needs or other needs related to the introduction of methods and means of information and communication technologies, participants in the educational process, as well as those who manage and provide this process.

As a result of various works [21, 22], it is concluded that organizations should strive to avoid integration by developing architectures and using information technologies that allow for building a coherent information system that can evolve over a long time. When purchasing software, organizations must consider both the immediate and deferred costs of integration.

Ready-made software products do not create a unified process management system, do not cover all objects and processes of activity, and do not take into account the characteristics of a particular university, and further investments are required in additional settings. The analysis of the existing management information systems indicates that the creation of such systems is moving along the path of automating certain areas of university activity [23, 24].

Discussing the results of our study, it should be noted that they have a certain difference, which lies in the very approach to modeling. More specifically, the key difference is which graphical modeling language we used. The methodological approach itself is not new, however, it is rarely used within the framework of our chosen field of study. Therefore, its application made it possible to present the result in a more convenient and detailed form, which better describes the scope of information support.

6. CONCLUSIONS

Summing up, it should be noted that the world trends in the development of both education and management of educational institutions are aimed at the transition to digital transformation. This means that all educational, scientific, managerial, and other processes of higher education must be completely transferred to the digital environment.

The model we have formed provides a systematic approach to data integration and the development of optimized databases that can underpin digital platforms and tools for teaching, learning, and university management.

As a result, we have obtained a model for the formation of databases for information support of the educational process for a single higher education. The study is limited by taking into account the specifics of the information system of only one such institution. Prospects for further research should be devoted to the expansion of modeling.

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