

MODEL FOR ASSESSING THE LEVEL OF DIGITALIZATION IN AN EDUCATIONAL INSTITUTION

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Abstract. This article is devoted to the creation of a model for analyzing, evaluating and monitoring the digitalization process in the educational environment. With the transition of higher education institutions to the credit system, the need for systems for identifying, calculating and accurately assessing academic performance indicators increases, this model is an attempt in this direction. The results of the experiment, the model proposed in the article, has the ability to determine their effectiveness, compare their productivity.

Key words: Digital economy in the education system, data warehouses, electronic document management systems, mathematical modeling, innovative management methods, algorithmic approaches, software, optimization, efficiency, digital methods and means.

Introduction

Currently, the issue of the existence of an effective and universal methodology for assessing the level of digitalization of enterprises, industries, economic sectors, etc. remains controversial in the scientific community. Existing methods developed to assess the scale of digitalization of countries or regions [1,2] due to the use of various criteria and indicators in international and national statistics demonstrate discrepancies in assessments of the level of digitalization [3,4,5]. In addition, many researchers analyzing the trends in the digitalization of higher education focus on the digital literacy of the population [6], the impact of information and communication technologies on the level of digitalization of education in general [7], and legal barriers hindering transformation [8]. A number of studies also note the insufficient level of funding for the digitalization of higher education [9,10,11].

Problems and solutions

Our goal should be to create a model for determining and assessing the level of electronic presentation of educational materials that organize and support the educational process in an educational institution. In a rapidly changing world, digitalization plays an important role in the creation, creation and use of modern information technologies. Currently, educational institutions

of the Republic of Uzbekistan do not sufficiently use electronic document exchange systems, the structures and content of information in which, considered as a source of educational material, are identical and often duplicated.

Let us assume that the data warehouse in an educational institution initially consists of information stored in deans' offices, departments, information technology centers, libraries and individual structures. In this case, the question arises of how much information is stored, what part can be accessed automatically, what part in the form of a simple file, what part in the form of a paper document.

Let the number of study areas in the institution be z , and N subjects need to be studied in them (the condition $N \geq z$ is always true) and educational materials for each course need to be prepared, as shown in Table 1.

Table 1

Educational materials for a specific i -subject and their parameters

№	Name of the educational material	Identifier	Material form		
			paper, in pages	electron, in bytes	verbal, in minutes
1	Subject program	O_1^i	$C_{O_1^i}$	$B_{O_1^i}$	$R_{O_1^i}$
2	Working curriculum	O_2^i	$C_{O_2^i}$	$B_{O_2^i}$	$R_{O_2^i}$
3	Methodological manual on pedagogical technology	O_3^i	$C_{O_3^i}$	$B_{O_3^i}$	$R_{O_3^i}$
4	Problem, set of tasks	O_4^i	$C_{O_4^i}$	$B_{O_4^i}$	$R_{O_4^i}$
5	Tests	O_5^i	$C_{O_5^i}$	$B_{O_5^i}$	$R_{O_5^i}$
6	General control questions	O_6^i	$C_{O_6^i}$	$B_{O_6^i}$	$R_{O_6^i}$
7	Glossaries	O_7^i	$C_{O_7^i}$	$B_{O_7^i}$	$R_{O_7^i}$
8	Abstract topics	O_8^i	$C_{O_8^i}$	$B_{O_8^i}$	$R_{O_8^i}$
9	Text of main lectures	O_9^i	$C_{O_9^i}$	$B_{O_9^i}$	$R_{O_9^i}$
10	Methodological instructions for final and current control	O_{10}^i	$C_{O_{10}^i}$	$B_{O_{10}^i}$	$R_{O_{10}^i}$
11	Methodological instructions for midterm control	O_{11}^i	$C_{O_{11}^i}$	$B_{O_{11}^i}$	$R_{O_{11}^i}$
12	Recommendations for independent work	O_{12}^i	$C_{O_{12}^i}$	$B_{O_{12}^i}$	$R_{O_{12}^i}$
13	Methodological instructions for course work	O_{13}^i	$C_{O_{13}^i}$	$B_{O_{13}^i}$	$R_{O_{13}^i}$
14	Presentations	O_{14}^i	$C_{O_{14}^i}$	$B_{O_{14}^i}$	$R_{O_{14}^i}$
15	Handouts (for laboratory work)	O_{14}^i	$C_{O_{15}^i}$	$B_{O_{15}^i}$	$R_{O_{15}^i}$
16	Problem book on practical work	O_{15}^i	$C_{O_{16}^i}$	$B_{O_{16}^i}$	$R_{O_{16}^i}$
17	Study manual	O_{15}^i	$C_{O_{17}^i}$	$B_{O_{17}^i}$	$R_{O_{17}^i}$
18	Video lecture	O_{16}^i	$C_{O_{18}^i}$	$B_{O_{18}^i}$	$R_{O_{18}^i}$
19	Textbook with stamp	O_{17}^i	$C_{O_{19}^i}$	$B_{O_{19}^i}$	$R_{O_{19}^i}$

20	References	O_{18}^i	$C_{O_{20}}^i$	$B_{O_{20}}^i$	$R_{O_{20}}^i$
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Let the number of objects (N) in the institution be calculated as follows.

$$N = \sum_{i=1}^z Wi \quad (1)$$

where W_i is the number of subjects (items) of the i -th educational direction listed in the working curriculum. Then, it is possible to create formulas (2) - (4), which allow calculating the volume of educational materials prepared in the institution on a page (C_{O_Y}), bytes (B_{O_Y}) and minutes (R_{O_Y}).

$$C_{O_Y} = \sum_{i=1}^n \sum_{l=1}^y C_{O^i l} \quad (2)$$

$$B_{O_Y} = \sum_{i=1}^n \sum_{l=1}^y B_{O^i l} \quad (3)$$

$$R_{O_Y} = \sum_{i=1}^n \sum_{l=1}^y R_{O^i l} \quad (4)$$

in these formulas $y = 20$, and the number n of subjects is equal to N . Each student in the process of studying writes papers, creates presentations, solves problems and tests, conducts thematic research during independent work, all this as an addition to the current, intermediate, final control. The accounting data for these and other tasks are given in Table 2.

Table 2

List of materials prepared by k -student for i -subject (approximate)

№	Name of the educational material	Identifier	Material form		
			paper, in pages	electron, in bytes	verbal, in minutes
1	Coursework	T_{i1}^k	$C_{T_{i1}^k}$	$B_{T_{i1}^k}$	$R_{T_{i1}^k}$
2	Abstract	T_{i2}^k	$C_{T_{i2}^k}$	$B_{T_{i2}^k}$	$R_{T_{i2}^k}$
3	Presentations	T_{i3}^k	$C_{T_{i3}^k}$	$B_{T_{i3}^k}$	$R_{T_{i3}^k}$
4	Exercises for retaking	T_{i4}^k	$C_{T_{i4}^k}$	$B_{T_{i4}^k}$	$R_{T_{i4}^k}$
5	Case studies	T_{i5}^k	$C_{T_{i5}^k}$	$B_{T_{i5}^k}$	$R_{T_{i5}^k}$
6	Development of programs	T_{i6}^k	$C_{T_{i6}^k}$	$B_{T_{i6}^k}$	$R_{T_{i6}^k}$
7	Written works	T_{i7}^k	$C_{T_{i7}^k}$	$B_{T_{i7}^k}$	$R_{T_{i7}^k}$
8	Writing articles	T_{i8}^k	$C_{T_{i8}^k}$	$B_{T_{i8}^k}$	$R_{T_{i8}^k}$
9	Reports on practice	T_{i9}^k	$C_{T_{i9}^k}$	$B_{T_{i9}^k}$	$R_{T_{i9}^k}$
10	Writing a master's or bachelor's thesis	T_{i10}^k	$C_{T_{i10}^k}$	$B_{T_{i10}^k}$	$R_{T_{i10}^k}$
11	Taking notes from lectures	T_{i11}^k	$C_{T_{i11}^k}$	$B_{T_{i11}^k}$	$R_{T_{i11}^k}$
12	Project work	T_{i12}^k	$C_{T_{i12}^k}$	$B_{T_{i12}^k}$	$R_{T_{i12}^k}$
13	Assignments for current control	T_{i13}^k	$C_{T_{i13}^k}$	$B_{T_{i13}^k}$	$R_{T_{i13}^k}$
14	Assignments for intermediate control	T_{i14}^k	$C_{T_{i14}^k}$	$B_{T_{i14}^k}$	$R_{T_{i14}^k}$
15	Final control work	T_{i15}^k	$C_{T_{i15}^k}$	$B_{T_{i15}^k}$	$R_{T_{i15}^k}$

Table 2 allows us to calculate the volume of educational materials prepared and submitted by all students in pages (C_T_Y), bytes (B_T_Y) and minutes ((R_T_Y), and these parameters are calculated using formulas (5) - (10).

$$CT_k = \sum_{i=1}^n \sum_{l=1}^y C_{-T^k il} \quad (5)$$

$$BT_k = \sum_{i=1}^n \sum_{l=1}^y B_{-T^k il} \quad (6)$$

$$RT_k = \sum_{i=1}^n \sum_{l=1}^y R_{-T^k il} \quad (7)$$

$$C_{-T-Y} = \sum_{j=1}^x CT_j \quad (8)$$

$$B_{-T-Y} = \sum_{j=1}^x BT_j \quad (9)$$

$$R_{-T-Y} = \sum_{j=1}^x RT_j \quad (10)$$

where x is the number of students at the university.

The mathematical representation of the qualification requirements and curricula of higher education, as well as the working curricula prepared by the educational institution, approved by the Ministry of Higher Education, for the field of knowledge, field of study and direction of education is given by formula (11).

$$\{S\} = (S_1, S_2, S_3) \quad (11)$$

Here S1 is a set of standard requirements for z-areas of study, S2 is a set of all curricula downloaded from the ministry, and finally S3 is a set of working curricula adopted by the university for existing areas of study and educational direction. They are calculated according to the following formulas.

$$\{S_1\} = (S_1^1, S_1^2, \dots, S_1^m) \quad (12)$$

$$\{S_2\} = (S_2^1, S_2^2, \dots, S_2^m) \quad (13)$$

$$\{S_3\} = (S_3^1, S_3^2, \dots, S_3^m) \quad (14)$$

where $m = N$.

Based on the above expressions and Table 3, formulas (15), (16) make it possible to calculate the volume of standard documents (requirements, educational and work curricula) used in the institution in pages (C_S) and bytes (B_S).

$$C_S = \left\{ \sum_{i=1}^n \sum_{l=1}^d C_{-S^i l}, \text{ if } S_{-S^i l} = 1 \wedge S_{-S^i l} = 2 \right\}, \quad (15)$$

$$B_S = \left\{ \sum_{i=1}^n \sum_{l=1}^d B_S^{il}, \text{ if } S_S^i_{l>}=1 \wedge S_S^i_{l<}=2 \right\}, \quad (16)$$

These mathematical expressions assume that both versions of these documents exist: paper and file, it is enough to see that $d = 2$.

Table 3

Mandatory documents required for a specific i-direction of study

№	Name of the field of study	Identifier	Document form	Volume, in pages	Volume, in bytes
1	Curriculum approved by the Ministry	S^i_1	$S_S^i_1$	$C_S^i_1$	$B_S^i_1$
2	Working curriculum adopted at the institution	S^i_2	$S_S^i_2$	$C_S^i_2$	$B_S^i_2$
3	Qualification requirements for obtaining a bachelor's or master's degree	S^i_3	$S_S^i_3$	$C_S^i_3$	$B_S^i_3$

The essence of the task was to find an answer to what extent an educational institution uses electronic document management systems when creating a data warehouse, and to create a model for determining and evaluating the parameters of the stages of a broad transition to a digital economy.

$$U_C_text = C_O_Y + C_T_Y + C_S \quad (17)$$

$$U_B_fail = B_O_Y + B_T_Y + B_S \quad (18)$$

$$U_R_nytk = R_O_Y + R_T_Y \quad (19)$$

where U_C_text , U_B_fail , U_R_nytk are the parameters that characterize the main indicators that can be collected in the educational institution during the learning process, respectively, in paper, electronic form and oral expression. To determine the level of electronic document management and digital systematization in an educational institution, the following criterion-model (20) can be proposed.

$$\max \left\{ \left\{ U_C_fail = B_O_Y + B_T_Y + \left\{ \sum_{i=1}^n \sum_{l=1}^d C_S^{il}, \text{ if } S_S^i_{l>}=2 \right\} \right\} \geq \left\{ U_C_text = C_O_Y + C_T_Y + \left\{ \sum_{i=1}^n \sum_{l=1}^d C_S^{il}, \text{ if } S_S^i_{l>}=1 \right\} \right\} \right\} \quad (20)$$

Experimentation and analysis of results.

Tashkent State University of Economics was chosen as the object of the experiment on the implementation of the functional capabilities of the model proposed in the article. The volume of documents submitted by 28 students of two groups of the Faculty of Information Technologies of Economics on 7 subjects during the winter session was analyzed. The source of information is a

questionnaire filled in by the students themselves. The volume of material prepared by students during the session was 1973 pages. Of these, 8394 pages are on paper, 7109 pages are in the form of file material, while the presence of both options at the same time is 3243 pages. 986 pages of oral information were received. To calculate the volume of educational materials prepared for the i - subject, we make table 4.

Table 4

The teaching materials on the i-subject presented by the experimental groups during the winter session

№	Name of the area of study	Identifier	Document form	Volume, in pages	Volume, in bytes
1	Subject program	O ⁱ ₁	3	12	140
2	Working curriculum	O ⁱ ₂	3	12	209
3	Methodological manual on pedagogical technology.	O ⁱ ₃	2	15	237
4	Problem, set of tasks	O ⁱ ₄	3	24	285
5	Tests	O ⁱ ₅	2	43	70
6	General control questions	O ⁱ ₆	3	11	153
7	Glossaries	O ⁱ ₇	3	8	52
8	Abstract topics	O ⁱ ₈	3	4	86
9	Text of main lectures	O ⁱ ₉	3	110	1139
10	Methodological instructions for final and current control	O ⁱ ₁₀			
11	Methodological instructions for midterm control	O ⁱ ₁₁	3	11	189
12	Recommendations for independent work	O ⁱ ₁₂	3	18	272
13	Methodological instructions for course work	O ⁱ ₁₃	3	48	427
14	Presentations	O ⁱ ₁₄	2	322	2752
15	Electronic textbook	O ⁱ ₁₅	2	214	25903
16	Video lecture	O ⁱ ₁₆	2		
17	Study manual with stamp	O ⁱ ₁₇	1	353	3242
18	Used literature	O ⁱ ₁₈	2	878	39286
	TOTAL		2	2083	74442

According to this table, more than 74 MB of data with 2083 pages were prepared for one subject. Taking into account that 103 subjects were taught in the faculty during the winter session, we form table 5 for one faculty.

Table 5

Volumes of educational materials prepared and used by students during the lesson

№	Material form	Prepared by students, in pages		Prepared by teachers, in pages	
		For two groups	By faculty	For one subject	By faculty
1	In paper	8394	92334	353	36359
2	In files	7109	78199	1472	151616
3	Existence of both forms	3243	35673	258	26574
4	Verbally submitted	986	10846		
	TOTAL	19732	217450	2083	214549

According to the results of this table, the parameter S_{T_Y} or materials prepared by students of the faculty amounted to 217450, and the inclinations of teachers — $S_{O_Y} = 214549$.

At the end of the experiment, we summarize the following indicators

$$U_{\text{sum}} = C_{O_Y} + C_S + C_{T_Y} = 214549 + 260 + 217450 = 432259$$

where U_{sum} is the volume of information in the educational process for a given faculty.

That is, in total, 4322599 pages of information were used in the educational process at the level of one faculty.

If we make calculations using formulas (17) - (19), the total volume of paper, file and materials in both representations at the faculty will be $U_{C_text} = 128629$, $U_{C_fail} = 229903$, $U_{C_dypl} = 62507$.

Let us calculate the comparison criterion using formula (20).

Let us put the above values into the formula $\max \{U_{C_fail} \div U_{C_text}\}$, the criterion requirement will be met, the U_{C_fail} index will be 1.78 higher than the U_{C_text} index, from which it is clear that 64% of the data is in file form, and 36% in paper form.

Conclusions. With the transition of higher education institutions to the credit system, the need for systems for identifying, calculating and accurately assessing academic performance indicators increases, this model is an attempt in this direction. The results of the experiment, whether at one faculty or at all departments, regardless of whether these data were collected tonight or earlier, the model proposed in the article has the ability to determine their effectiveness,

compare their productivity. In the future, the results of expanding the model in terms of determining the advantages, efficiency coefficients of using modern information and communication tools in lessons will be announced. This model can be applied in other educational institutions regardless of the form of education. Of course, other documents: library collection or other information resources, such as teachers' articles, online distance learning products, working with big data for education, etc., indicate the need to continue this research in the future.

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