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Algorithm for Managing the Quality of Educational Information System

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ABSTRACT
The paper considers the problem of assessing the quality of educational information systems in the context of the digital transformation of society. An algorithm for determining the quality of information systems based on expert information is proposed. This approach differs in that it allows one to formalize qualitative assessments of the state of the system using the theory of fuzzy sets. The fuzzy quality assessment models included in the methodology, as well as the algorithms corresponding to them, allow, based on expert data, to assess the quality of educational information systems at the stage of their development, implementation and use. The implementation of the methodology makes it possible to increase the efficiency of the quality management process of educational information systems and the educational process as a whole.
Keywords: *educational information system, quality of information systems, digitalization of education*

1. INTRODUCTION

The trend towards digitalization of all spheres of society, undoubtedly, has become a prerequisite for the introduction of electronic technologies in the field of education. And if at the dawn of the new technical revolution "digital" penetrated the higher education system, then the 2020-s were marked by the digitalization of secondary schools as a kind of addition to the traditional one. After 2018, the paradigm of active implementation of online courses has strengthened in higher educational institutions, including the practice of replacing (on an alternative or non-alternative basis) traditional disciplines by distance learning. These practices provoked heated discussions, since not all disciplines turned out to be meaningfully and methodically adaptable to the online format. However, no one considered the option of a complete transition "to digital" as the only correct one.
The problems caused by the coronavirus pandemic have affected all spheres of public life, including education. If earlier mainly higher educational institutions, interested in reaching the audience and implementing projects of lifelong and accessible education, gravitated towards the remote conduct of the educational process, then forced self-isolation led to the fact that distance technologies, which are poorly demanded by the school, have become an urgent need. The massive transition of all schools to online education clearly demonstrated the problem of assessing the quality of educational information systems, the relevance of which was missed in "peacetime", since an increase in the load on these systems led to various negative consequences, for example, educational portals that were not designed for a one-time stay of a large number of users did not cope with the load and errors occurred, as a result of which students could not receive the assignment.
The problem of assessing the quality of any information system, including educational (EIS), lies in the absence of a unified definition of the term "IS quality" - neither in the state standards of the Republic of Uzbekistan and the CIS countries, nor in international regulatory legal acts, as a result of which every scientist in his scientific works, works on IS quality management, interprets it in his own way. There is no unified view of the set of indicators for assessing the quality of EIS, and the existing approaches do not fully take into account the specific features of the problem of assessing the quality of EIS, first of all, the presence of subjective uncertainty associated with the need for widespread use of expert information.

2. METHODS

In this regard, an attempt was made independently, based on data obtained from various sources, to formulate the concept of "EIS quality" and determine its constituent elements. As a result, the criterion "EIS quality" was formulated, which is characterized by the following parameters: ergonomics, efficiency, consistency, reliability, safety, functionality. In turn, each of them can be characterized by additional parameters. From the point of view of the requirements for the educational component, the requirements for the EIS are put forward - the quality of infrastructure, the quality of work programs, the quality of knowledge and the safety of educational content.
To solve this problem, it is required to regulate the procedure for combining the available data on the quality level of the EIS.

The study of the subject area has shown that the quality of the EIS is influenced by parameters, the prevailing part of which is not possible to quantify [6]. Their value is most often determined by experts, relying on a subjective analysis of the system's functioning process and evaluating it verbally, i.e. qualitative assessments. However, some parameters can still be quantified. Thus, for the procedure of combining the available data on the quality level of the EIS, it is necessary to use a mathematical apparatus that will allow the combined use of quantitative and qualitative information characterizing the subject area [9].

Fuzzy cognitive modeling was chosen as the most appropriate approach for solving this problem. Its choice is related to the fact that it allows you to formalize factors that are difficult to measure numerically, and also makes it possible to use unclear, incomplete and contradictory data [1].

At present, cognitive modeling is increasingly used to solve poorly formalized problems, where it is required to structure the knowledge of experts and take into account their disparate opinions to develop an agreed solution [8]. This approach is actively used in decision support systems to analyze problem situations using simulation.

To calculate the assessment of the quality of the EIS, it is necessary to formulate mathematical models that connect the initial information about the assessments of the current and "future" quality level of the IP. To identify the list of initial data for the models being developed, the rules for their use for calculations, it is necessary to unify the algorithm for assessing and managing the quality of the EIS at all stages of its life cycle. For this, it is necessary, first of all, to define these stages.

Let's turn to the regulatory legal acts. International standard ISO / IEC 15288: 2002 "System engineering - System life cycle processes" defines the life cycle of systems that are "created by people", i.e. artificial systems. The analysis of this standard made it possible to identify the following stages of the IPO life cycle:

1. Design of EIS

This stage includes justification of the need to create an EIS, analysis of requirements for it, development of technical specifications, study of the subject area, development of a draft design, technical design, working documentation and debugging before commissioning.

2. Commissioning of EIS

At this stage, the informatization object (educational institution) is being prepared for the implementation of the EIS, namely, personnel, equipment are being prepared, construction and installation work (structures, installation of communication lines) is carried out, if necessary. After these procedures, there is a direct implementation, primary testing on a limited circle of users. Also at this stage, the system is filled with content.

3. Operation of the EIS and maintenance of its work

At this stage, changes are made when errors are detected or in order to improve the system itself, for example, expanding the existing functionality or service area (adding new courses or educational technologies).

4. Decommissioning

At this stage, the EIS, at the will of the decision-maker, is decommissioned, the equipment necessary for its operation is dismantled. If necessary, the data is transferred to the new system.

Taking into account the identified stages of the EIS life cycle, an algorithm for managing its quality was developed, the block diagram of which is shown in Fig. 1. It outlines the procedures that relate to the quality management of the EIS, namely:

1. Formation of requirements for the EIS (from teachers, students and the management of the educational institution, as well as the requirements of the regulator). The resulting information of this stage is a list of non-formalized requirements for the quality of the IP, determined by its various characteristics.

2. Combining data on the required level of quality of the EIS. The result is a formalized level of EIS quality. In addition, at this stage, you can also set a promising level of quality of the EIS, in case the system is planned to improve over time.

3. Creation (improvement) of the EIS concept. This procedure is aimed at meeting the requirements of clause

4. Assessment of the level of quality that is achieved by implementing the EIS concept. If even at the planning stage of the EIS the level of its quality is insufficient, the concept must be revised. As a result of an attack on the EIS, the level of its quality may decrease. As a result of the implementation of clause 4, the person making the decision receives a formalized assessment of the quality of the EIS in the event of a possible attack.

5. Checking the quality level of the EIS obtained in clause 4 for compliance with the required level. As a result, the decision maker receives recommendations on whether it is necessary to make changes to the information security system or change the concept of the EIS in order to meet the required level of quality.

6. Assessment of the current level of quality of the EIS. As a result of this stage, an assessment of the current level of quality of the EIS is obtained. This indicator gives the decision maker information about the quality of the EIS at the present time.

Each of the stages of the OIP quality management algorithm shown in the flowchart should be described in the regulatory documents. These documents include:

– EIS quality manual (contains the policy, goals and objectives of quality management and is fundamental in the quality management process);
– Instructions for the formation of the required level of quality of the EIS (determine the rules of specific work within any quality management process, including the elimination of the consequences of attacks on the information security of the EIS);
– The quality management plan (reflects the "reference" terms within which certain procedures are carried out, on its basis, work is carried out to modernize the EIS and its constituent elements);
– Acts of work performed (necessary for reporting and providing data on the state of the system at a particular point in time).

As part of solving the problem of quality management of the EIS, it is advisable to use international regulatory legal acts, while it is best to refer to primary sources (EIS series standards). However, in some cases it was advisable to refer to Russian interstate standards (see table).

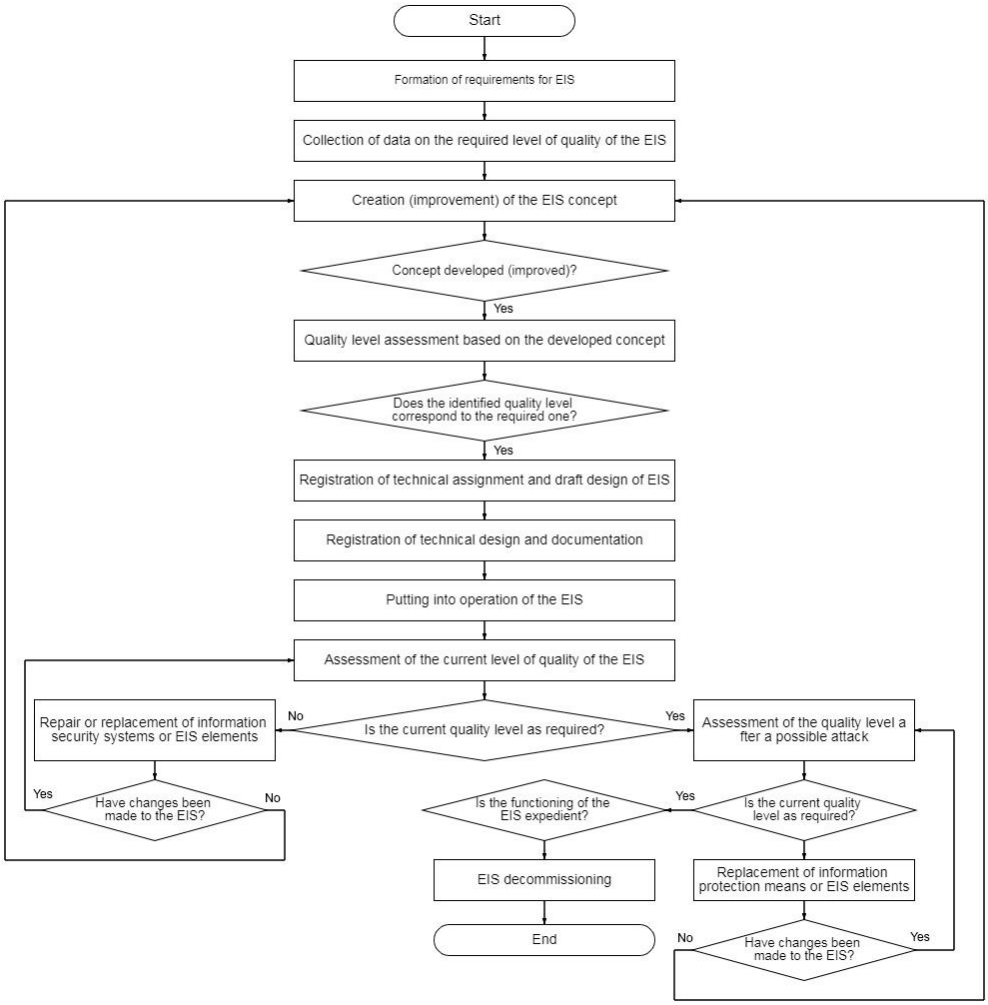

Figure 1 Algorithm for managing the quality of EIS

Table 1 Application of international standards in the framework of the problem being solved [3-5, 10]

№	Standard name	The state	Domain object	The problem for which the standard is applied
1	GOST 27.002-89 "Reliability in technology Terms and Definitions"	RF (USSR)	EIS quality	RF (USSR) Definition of the concept of "quality" and the process of its management in the EIS
2	ISO 9001:2015 «Quality management systems – Requirements»	International		Quality management process in EIS
3	ISO 8402:1994. «Quality management and quality assurance»	International (obsolete)		List of building blocks for determining the quality of EIS
4	SO/TR 10013:2001 "Guidelines for quality management system documentation"	International		Documenting the quality management process
5	ISO/IEC 15288:2002 «System engineering - System life cycle processes	International	EIS life cycle	Determination of the main stages of the life cycle of the EIS
6	GOST 34.601-90 "Automated systems: stages of creation"	RF (USSR)		

It should be noted that the planning and implementation of the EIS quality management process is successfully carried out using various project management methodologies. (Agile, Canban) [12]. These methodologies are implemented using software products, both installation and cloud solutions. They have the functionality to distribute tasks over time and resources, estimate the costs of various resources for project implementation. However, these solutions cannot automatically keep track of costs and take into account price increases.

3. RESULTS

Thus, the EIS quality management process can be represented as the following sequence of steps:
1. Setting the required level of EIS quality
2. Assessment of the quality level of the EIS at the current time
3. Assessment of the EIS quality level in case of threat realization.
Each of these steps serves a different purpose and assumes the use of dissimilar inputs.
As part of solving the problem of combining data on the required level of quality of the EIS and assessing its quality, there is an aggregate criterion for assessing quality, which is formulated on the basis of international standards of the ISO 9000 series and various groups of quality indicators that can be formulated by decision makers.

$$Quality = (\alpha_1 \cdot Safety + \alpha_2 \cdot Eco + \alpha_3 \cdot Sist + \alpha_4 \cdot Sec + \alpha_5 \cdot Rel + \alpha_6 \cdot Func + \alpha_7 \cdot Know + \alpha_8 \cdot Inf + \alpha_9 \cdot Prog) * Law$$

where respectively $\alpha_{1,}\alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8, \alpha_9 \in [0; 1]$, influence factors ergonomics (Safety), economy (Eco), consistency (Sist), reliability (Rel), security (Sec), functionality (Func), quality of knowledge (Know), infrastructure (Inf), quality of curricula (Prog), compliance with the EIS content requirements of the law on age marking (Law $\in [0; 1]$) to the quality level of the educational information system (Quality).
The use of additive convolution to solve the problem is due to the fact that a decrease in an indicator according to one criterion is compensated by an increase in the assessment of other indicators. In this case, the compensation of one indicator with another depends on the value of α_i. The use of multiplicative convolution within the framework of this task is used to take into account legal requirements, since a high indicator of other quality criteria cannot compensate for illegal content, which leads to zeroing of the EIS quality level.
After assessing the possible level of quality of the EIS in the event of an attack, the decision maker decides whether it is advisable to increase it. This process is carried out based on the results of comparing the required quality level of the EIS with the possible one. The comparison is carried out by finding the absolute deviation Δ:

$$\Delta = Quality_p - Quality, \quad (1)$$

where $Quality$ – is the possible level of quality of the EIS in the event of an attack; $Quality_p$ - the required level of quality of the EIS.
Index Δ is fuzzy. To quantify it Δ', defuzzification operation required. For this, it is proposed to use the centroid method, within which the centroid of the trapezoid is calculated: $\Delta_d = \frac{\int_{a_1}^{a_4} x\mu(x)dx}{\int_{a_1}^{a_4} \mu(x)dx}$, where Δ_d – de-diffusion result; a1 and a4 – abscissa of the lower base of a fuzzy number; $\mu(x)$- its membership function [12].
If the deviation indicator is in the unacceptable, according to the decision maker of the EIS, limits, then the procedure begins to increase the possible level of quality of the EIS in the event of attacks on the required level and further recalculation of the value Δ_d.
Taking into account the above-described EIS quality management scheme, the procedure for increasing the possible level of quality can occur at the stages of planning, modernization and operation. At the same time, it is important to note that increasing the possible level of quality of the EIS in the event of an attack involves changes not only in order to eliminate or reduce existing vulnerabilities or the impact of threats on the EIS, but also in order to reduce the cost of operating the IP and increase the socio-economic effect.

4. CONCLUSIONS

Within the framework of this article, the problem of assessing the quality of educational information systems in the context of the digital transformation of society is shown, as well as its solution using fuzzy cognitive modeling as a mathematical apparatus. The authors have proposed an aggregate criterion for assessing the quality of EIS, reflecting the complex influence of various disparate indicators that characterize the quality of EIS in their own way. The formula for calculating the indicator "quality of EIS" is an additive and multiplicative convolution of a number of indicators - ergonomics (Safety), efficiency (Eco), consistency (Sist), reliability (Rel), safety (Sec), functionality (Func), quality of knowledge (Know), infrastructure (Inf), quality of curricula (Prog), compliance with the EIS content requirements of the law on age marking (Law). The use of the criterion "quality of the IPO" allows you to increase the information content of its assessment, which, in turn, increases the efficiency of quality management of the IPO.
On the basis of the results obtained, an algorithm for managing the quality of the IP was described, which includes an algorithm for assessing the current and possible level of quality of the EIS in the event of an attack. Its peculiarity lies in the fact that it takes into account the poor formulation of linguistic assessments of experts and allows interpreting qualitative indicators into quantitative ones.

REFERENCES

[1] I.M. Azhmukhamedov, O.M. Protalinsky, Methodology for modeling poorly formalized poorly structured socio-technical systems, Vestnik AGTU. Ser. Management, computer technology and informatics, 1 (2013) 144-154.

[2] I.M. Azhmukhamedov, Information Security. System analysis and fuzzy cognitive modeling: monograph, Moscow: LAP LAMBERT Academic Publishing GmbH & Co. KG. Astrakhan, 2012, 385 p.

[3] GOST R ISO, IEC 27005-2010 Information technology, Security methods and means, Information security risk management, Electronic fund of regulatory and legal documentation. http://docs.cntd.ru/document/1200084141

[4] GOST ISO 9000-2011 Quality management systems, Fundamentals and vocabulary, Electronic fund of regulatory and legal documentation. http://docs.cntd.ru/document/1200093424

[5] GOST 27.002-89. Reliability in technology. Basic concepts. Terms and Definitions. Electronic fund of legal and normative-technical documentation. http://docs.cntd.ru/document/gost-27-002-89

[6] L.V. Glukhova, Methodology for assessing and managing the quality of information systems functioning, Bulletin of Kazan Technological University, 4 (2008) 174-181.

[7] M. Eppler, D. Wittig, Conceptualizing information quality: A review of information quality frameworks from the last ten years, Proc. of the 2000 Conference on Information Quality, Klein, B. D. & Rossin, D. F. (eds.); Boston: M.I.T. 2000, pp. 83-91.

[8] E.S. Kryukova, I.B. Paraschuk, A mathematical model designed to assess the quality of an electronic library: synthesis of the number of gradations of the state space, Caspian journal: management and high technologies, 1 (2020) 121-131.

[9] O.P. Kuznetsov, Cognitive modeling of poorly structured situations, 2005. http://posp.raai.org/data/posp2005/Kuznetsov/kuznetsov.html

[10] International standard ISO 9000-2015. Quality management systems. http://iso-management.com/wp-content/uploads/2018/09/ISO-9000-2015.pdf

[11] R. Prieto-Diaz, The Common Criteria Evaluation Process: Process Explanation, Shortcomings, and Research Opportunities, Harrisonburg, Virginia: James Madison University, USA, December 2002, 56 p.

[12] P.P.B. Rao, N.R. Shankar, Ranking generalized fuzzy numbers using area, mode, spreads and weight, Int. J. of Applied Science and Engineering, 10(1) (2012) 41–57.