INFORMATION AND ANALYTICAL SYSTEM FOR OBTAINING AN INTEGRATED ASSESSMENT OF THE QUALITY OF EDUCATIONAL SERVICES FROM THE POSITION OF CONSUMERS

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Abstract. The aim of the research study is the description of the information analytical system developed by the authors for the formation of an integral linguistic assessment of the quality of educational services from the perspective of three main groups of consumers: employers, students and young professionals. The computation of the integral linguistic quality assessment is based on specially structured information obtained in the course of a voluntary online survey of consumers on specialized quality criteria for groups. A site has been developed for the online survey. The algorithmic support of the information-analytical system is based on the methods SERVQUAL, SWOT-analysis and fuzzy linguistic information processing technologies. The tools of the information analytical system allow us to obtain: linguistic assessments of the quality of services from the perspective of each group of consumers, an integral quality assessment for all consumers and automatically build a SWOT analysis matrix to develop a strategy to improve the quality of the analysed services. In accordance with modern standards of quality management, the approach to quality assessment laid down in the methodology for generating results uses the assumption that the consumer assesses the quality of services based on a comparison of his/her expectations and perceptions of the service during its receipt.
Keywords: consumers of educational services, education, quality of educational services, SWOT –analysis.

Introduction

The aim of the research study is the description of the information analytical system developed by the authors for the formation of an integral linguistic assessment of the quality of educational services from the perspective of three main groups of consumers: employers, students and young professionals.

The problem of assessing the quality of educational services from the perspective of the labour market and the main groups of consumers of these services is an actual topic of theoretical and practical research. The quality level of the educational services provided largely determines the competitiveness and effectiveness of the work of universities. From the position of the labour market, the assessment of the quality of educational services plays the role of active interaction and is a tool for employers to indirectly influence the implementation and orientation of the training of young professionals. A work by E.V. Novatorov (Novatorov, 2001) describes the structuring of educational institutions as organizational systems operating in two interconnected markets: in the educational services market, providing educational programmes as services to students, and in the labour market indirectly through their graduates, who in the process of learning have acquired competencies, characterizing the quality of their workforce for enterprises-employers.

Quality assessment through surveys, questionnaires and other forms of obtaining information from consumers is a means of feedback and allows you to create corrective measures aimed at the practice-oriented development of educational services. There is a lot of research by Russian and foreign scientists in the field of creating tools for processing the results of questioning, structuring, statistical and causal analysis of the information received. In the works by Ermakova & Nikulina (2017), the features of quality assessment are formulated and highlighted from the position of the state, employers and students. On the basis of the results of the questioning of students of Orenburg State University, the following tools were demonstrated: identifying the strengths of the university's activities from the perspective of graduates, obtaining assessments of the compliance of the structure of the curriculum and the content of educational curriculum programmes with graduates, teachers and employers. The survey of graduates and students was conducted in 2016 as part of the annual study "Graduate of OSU", more than 2000 graduates took part, and based on the results of processing the information received, practical recommendations were developed aimed at improving the organization of the educational process. A paper by I.V. Toropov (2016) shows the model of monitoring and assessing the quality of educational services of the university. The most important unit of this model is "Observing and analysing the quality of service", focused on receiving feedback and joining in a single ring of stages "Studying the requirements of interested persons" - "Implementing services" - "Determining the satisfaction of interested persons". In this block, the characteristics of the service implementation are compared with the requirements of quality standards and the development of corrective measures.

The information analytical system proposed in this paper that forms the criterial matrix chart and obtains an integrated, labour market-oriented assessment

of the quality of educational services from the position of the main consumer groups is based on the SERVQUAL method (Toropov, 2016). The SERVQUAL methodology formalizes the idea that quality assessment in the service sector should be based on a consumer's comparison of the level of expectation of quality before consuming a service with the level of quality perception at the moment it is received. The implementation of this technique is reduced to processing specialized questionnaires consisting of a set of assessments presented in a five-point Likert scale according to different criteria for different consumer groups: the level of service expectancy by criterion, the level of quality perception by criterion, the level of importance of a criterion. In contrast to the classical technique SERVQUAL, the technology incorporated in the information analytical system proposed in the work is implemented by means of fuzzy linguistic information processing methods. The use of fuzzy linguistic methods of information processing allows you to significantly expand the set of tools for analysing the results of the survey by simulating consumer responses using linguistic variables and constructing rules for fuzzy inference. The fuzzy inference unit provides an opportunity to take into account various aspects of expert opinion when assessing the degree of inconsistency between consumers' expectation and perception regarding service quality criteria. According to the results of a survey using methods for processing fuzzy linguistic information, a matrix of SWOT analysis is built, which allows you to identify the strengths and weaknesses of the university. The methods of convolution of linguistic criteria provide an opportunity to form various averaging strategies in the development of group opinion and build various structures of the integral index of the quality of educational services.

Description of the methodology, algorithmic support and basic units of work with the information analytical system

We describe the sequential blocks of work with the information analytical system proposed as part of the study, revealing the main aspects of the methodology and algorithmic support embedded in their implementation.

Block 1. Questioning of major consumer groups. A survey questionnaire is created for each group of educational service consumers. The questionnaire includes three blocks (criteria) of questions, reflecting the three main directions of assessing the quality of educational services from the perspective of this class of consumers. For example, the structure of the employer questionnaire is presented in Figure 1 (compiled by the authors).

In the process of answering each question of the questionnaire, three positions are filled in on a one-hundred-point scale: "expectation", "perception", "importance". You can complete the questionnaire procedure on a specially

designed website. A fragment of the website is shown in Figure 2 (compiled by the authors).

Educational potential of the young specialist	• Theoretical knowledge of the profile of the received specialty • Practical training in the profile of the received specialty • Computer skills • Legal literacy • Business communication skills, speech culture • Ethical behavior
Motivation for professional growth of a young specialist	• Readiness for advanced training in short courses (lasting from 1 to 3 months) • Readiness for advanced training in long-term courses (lasting over 3 months) • Willingness to receive a second higher education • Willingness to study in graduate school • Readianess for official travel • Willingness to master related and additional professions and specialties
Personal qualities of a young specialist	• Initiative at work • Ability to work in a team • Ability to work independently • Ability to make decisions • Susceptibility to innovations, innovations • Leadership skills • Sociability

Figure 1 **Structure of the questionnaire for employers** *(compiled by the authors)*

Answers to each position of each question are modelled as linguistic variables (Parasuraman, Berry, & Zeithaml, 1988) defined by a tuple $\langle K,T,U \rangle$ (K - variable name, $T = \{T_1, T_2, ..., T_N\}$ - term set of variable values, base set U). Positions "expectation" and "perception" are modelled by linguistic variables $K^{'}$, $K^{''}$ that have the same term set, set on a 100-point base scale. The "importance" position is modelled by a linguistic variable V with a term set

$G = \{G_1, G_2, G_3, G_4, G_5\}$ (G_1 - «very low degree of importance», G_2 - «low degree of importance», G_3 - «medium degree of importance», G_4 - «high degree of importance,», G_5 - «very high degree of importance»), terms of which are also given on a 100-point base scale. The formation of a fuzzy set of the base scale corresponding to a certain term T_j (G_k) is reduced to the construction of the membership function $\mu_{T_j}(u)$ ($\mu_{G_j}(u)$), the values of which for each $u \in U_i$ represent the degree of correspondence of the number of points $u \in U_i$ to the term T_j.

In the process of constructing functions $\mu_{T_j}(u)$ it is assumed (Borisov, Alekseev, & Krumberg, 1982): the numbering of terms is such that a term with a left-sided carrier has a smaller number; $\mu_{T_1}(u_{\min}) = 1$, $\mu_{T_N}(u_{\max}) = 1$; for any $i(i+1 \le N)$ $0 < \max\limits_{u \in U} \mu_{T_i \cap T_{i+1}}(u) < 1$; for each number i there $u \in U : \mu_{T_i}(u) = 1$; for anyone T_i $\sum\limits_{u \in U} \mu_{T_i}(u) > 1$.
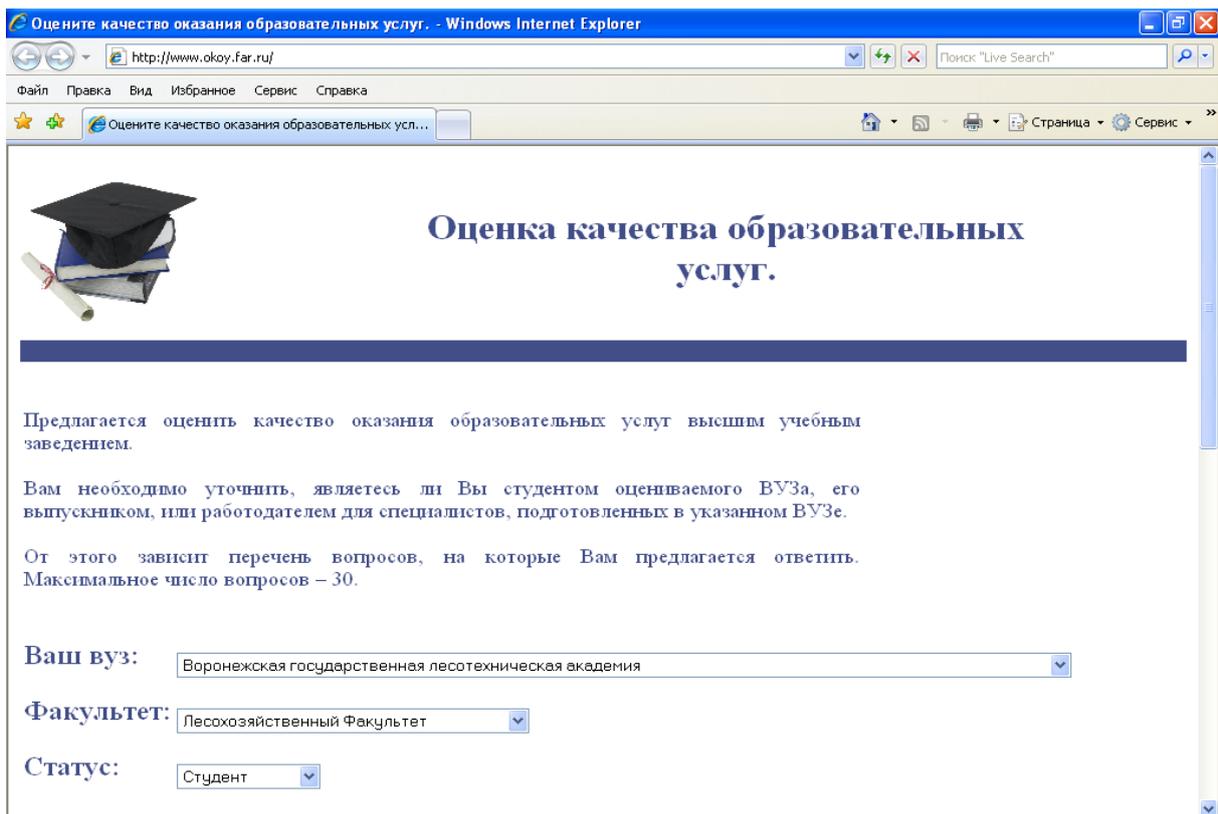
*Figure 2 **Fragment of the website** (compiled by the authors)*

Block 2. Formation of rules for obtaining quality assessments on the basis of filled in "waiting", "perception" positions. Linguistic variables are introduced: Y' - quality by issue, Y - quality by criterion. The term set of these variables has the form $S = \{S_1, S_2, ..., S_5\}$, where S_1 - «very low quality by criterion», S_2 - «low

quality by criterion», S_3 -« average quality by criterion», S_4 -« high quality by criterion», S_5 - « very high quality by criterion». As a base set for constructing terms, a set is used $U = \{1,2,...,100\}$. Membership functions $\mu_{S_j}(u)$ coincide with the corresponding membership functions $\mu_{G_j}(u)$ of the terms G_j of the linguistic variable "importance".
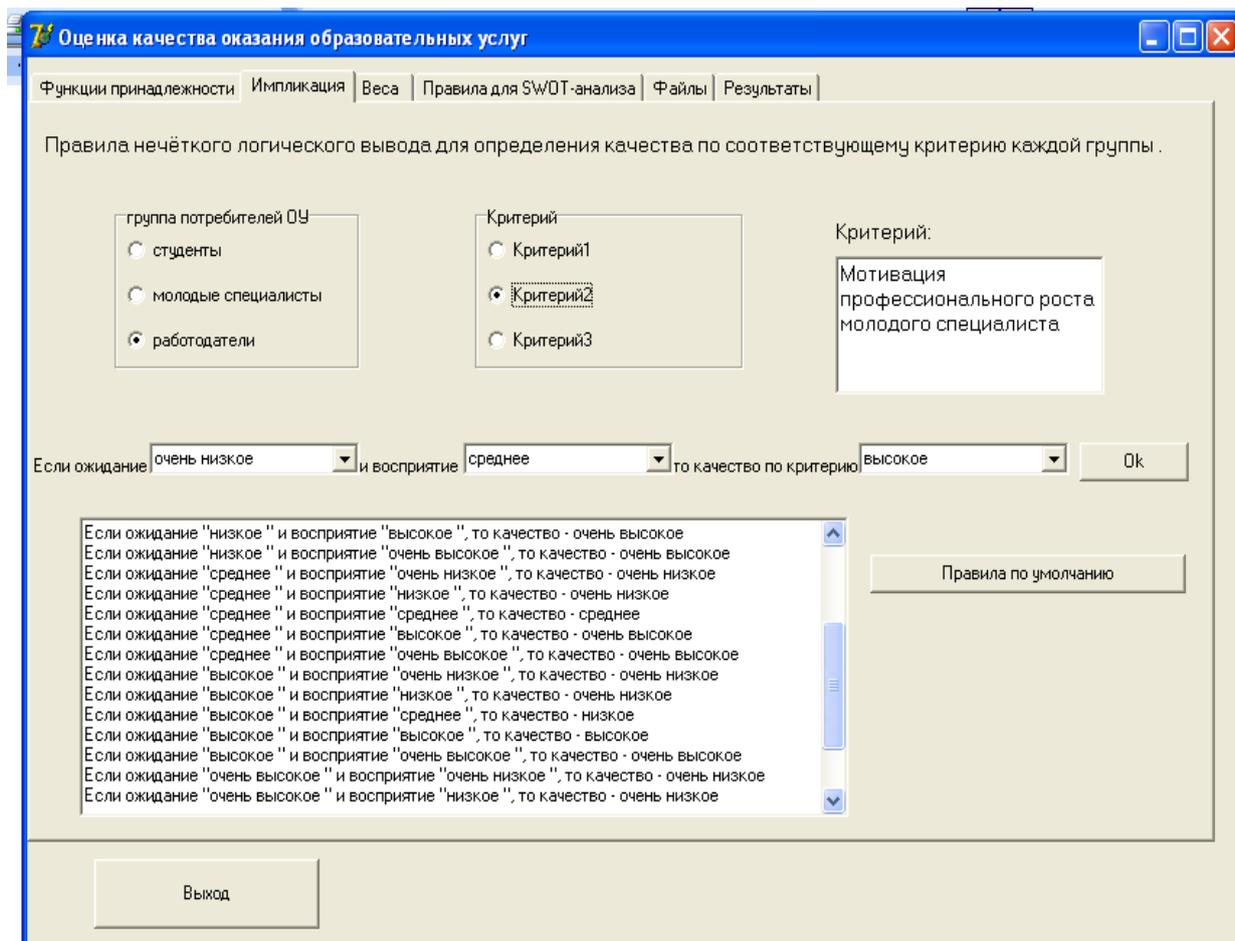
Figure 3 **Fragment of the work of the information analytical system for the input of fuzzy inference rules** *(compiled by the authors)*

The device, based on the rules of fuzzy inference (Azarnova, Kretinina, & Stolbovskaya, 2008), allows for each question of the completed questionnaires to display linguistic variables $K^{'}, K^{''}$ ("expectation", "perception") in the resulting quality variable Y' and to get a point estimate of the resulting variable. For each criterion, a set of rules of the form is built by an expert « D_k : if $K'=T_j$ and $K''=T_i$ then $Y = S_l$ ». Processing the rules and obtaining point estimates is carried out using special methods for implementing fuzzy implication. The information analytical system under consideration uses a fuzzy implication of Lukasevich (Parasuraman

et al., 1988). As a result of working with the rules, a point numerical quality assessment is formed $E \in [1,100]$. To go to the linguistic term of the variable "quality", a simple search is used, the essence of which is to calculate the measure of membership $\mu_{S_i}(E)$ for all S_i and select the term S^* with the largest measure of membership. Figure 3 shows a fragment of the work of the system for experts to draw up rules for fuzzy inference.

<u>Block 3</u>. Formation of a generalized quality assessment of the criteria (blocks of questions) for each questionnaire. To construct a point quality estimate for each criterion, an additive linear convolution of point estimates is used for questions related to this criterion. The weights w_i used in the formation of convolution are calculated by an expert and reflect the contribution of the question to the formation of the criterion under consideration. After receiving a point estimate using the simple enumeration method, the system forms the corresponding term of "quality" according to the criterion Y.

<u>Block 3</u>. Formation by each criterion of each group of consumers averaged over the totality of questionnaires indicators of "importance" V and "quality" Q. The system uses LOWA - the ordinal averaging (aggregation) operator to calculate averaged indicators (Borisov, Alekseev, & Merkurieva, 1989):

$$\Phi_W(L_1,...,L_n) = C^n\{(w_k,P_k), k=1,...,n\} = w_1 \otimes P_1 \oplus C^{n-1}\{(\beta_h,P_h), h=2,...,n\}, \qquad (1)$$

where $W = (w_1,...,w_n)$ - weights vector ($w_i \in [0,1]$, $\sum_{i=1}^{n} w_i = 1$), $P = (P_1,...,P_n)$ - ordered by non-ascending linguistic terms vector $L = (L_1,...,L_n)$, $\beta_h = \dfrac{w_h}{\sum_{k=2}^{n} w_k}, h=2,...,n$, C^n - combination of n terms, the calculation of which is reduced to the sequential convolution of two terms by the formula:

$$C^2\{w_i, P_i, i=1,2\} = w_1 \otimes F_j \oplus (1-w_1)F_i = F_k,$$
$$j \geq i, \quad P_1 = F_j, P_2 = F_i, \quad k = \min\{n, i + round(w_1(j-i))\}. \qquad (2)$$

The principle of averaging using the linguistic OWA-operator is determined by the choice of the weights vector $W = (w_1,...,w_n)$. The weights vector $W = (w_1,...,w_n)$ can define the following averaging principles (Azarnova, Kretinina, & Stolbovskaya, 2008): the average estimate should not be higher than the lowest one of collapsible estimates — the conjunctive strategy; the averaged estimate coincides with the highest one of collapsed estimates - the disjunctive strategy;

the average score implements a compromise between collapsible estimates - the compromise strategy.

The disjunctive strategy corresponds to the weights vector $W = (1,0,0,...,0)$, conjunctive - $W = (0,0,0,...,0,1)$, compromise - $W = \left(\dfrac{1}{n},\dfrac{1}{n},\dfrac{1}{n},...,\dfrac{1}{n},\dfrac{1}{n}\right)$ Along with these "pure" strategies, there are hybrid strategies, the functional representation of which is given by the parametric family of operators. For arbitrary use when aggregating the weight vector $W = (w_1,...,w_n)$, the function

$$orness(W) = \frac{1}{n-1}\sum_{i=1}^{n}(n-i)w_i \qquad (3)$$

characterizes a measure of proximity to a disjunctive strategy, and the value $andness(W) = 1 - orness(W)$ characterizes the measure of proximity to the conjunctive strategy. If value $orness(W) > 0.5$, then the corresponding OWA operator is called quasi-disjunction. If value $andness(W) < 0.5$, then - quasi-disjunction. Function values

$$tradeoff(W) = 1 - \sqrt{n\sum_{i=1}^{n}\frac{\left(w_i - \dfrac{1}{n}\right)^2}{n-1}}, \qquad (4)$$

characterize the compensation properties of aggregation operators, the closer the value $tradeoff(W)$ to 1, the higher the compensation properties of the operator. Weights vectors can be formed using linguistic quantification functions $Q:[0,1] \rightarrow [0,1]$, $Q(0) = 0$, $Q(1) = 1$. The community quantifier is given by the quantification function:

$$Q_\forall(x) = \begin{cases} 0, & \text{if } 0 \le x < 1 \\ 1, & \text{if } x = 1 \end{cases}, \qquad (5)$$

quantifier of existence:

$$Q_\forall(x) = \begin{cases} 1, & \text{if } 0 < x \le 1 \\ 0, & \text{if } x = 0 \end{cases}, \qquad (6)$$

quantifier "at least $m\,(m \in Z_+)$»:

$$Q(x) = \begin{cases} \dfrac{x}{1/m}, & \text{if } x < \dfrac{1}{m} \\ 1, & \text{if } x \ge \dfrac{1}{m} \end{cases}, \qquad (7)$$

quantifier "most"

$$Q(x) = \begin{cases} 0, & \text{if } x < a \\ \dfrac{x-a}{b-a}, & \text{if } a \le x < b . \\ 1, & \text{if } x \ge b \end{cases} \qquad (8)$$

With the help of quantification functions, the weights of linguistic OWA operators Φ_Q that implement the corresponding properties are calculated as follows:

$$w_1 = Q\left(\frac{1}{n}\right), \quad w_i = Q\left(\frac{i}{n}\right) - Q\left(\frac{i-1}{n}\right), \left(i = \overline{1,n}\right). \tag{9}$$

<u>Block 4</u>. Implementation of the SWOT-analysis (Uchitel' & Uchitel, 2014) based on the results of the calculation of the averaged estimates of "quality" Q_i and "importance" V_i for all criteria of all consumer groups. Experts form the rules, on the basis of which from a variety of criteria are selected subsets that can be attributed to the strengths, weaknesses, as well as opportunities and threats for the development of services. The rules have the form "if $Q_i = (\geq, \leq)S_k$ [and $V_i = (\geq, \leq)G_m$]», then the criterion is a strong point (weak point, opportunity or threat). Figure 4 shows the results of a SWOT analysis for a demo.
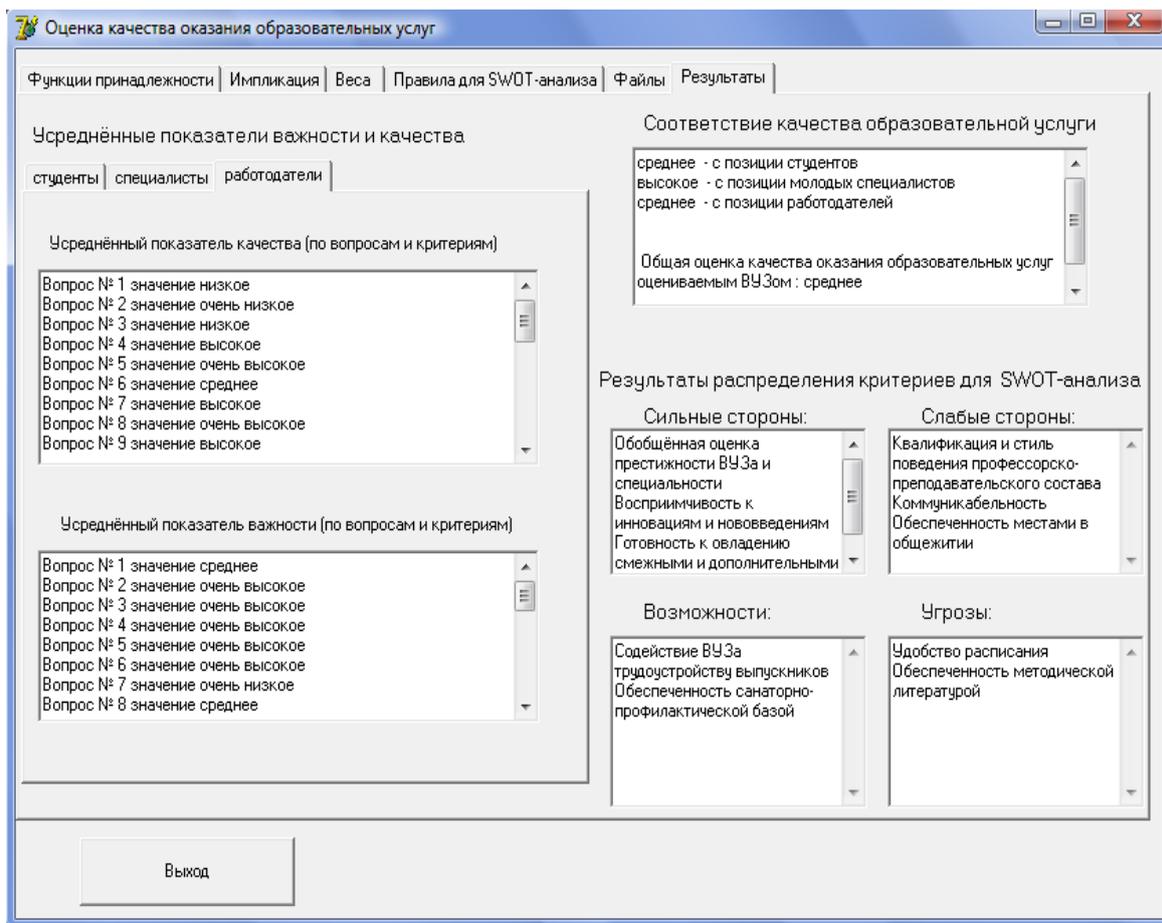
*Figure 4 **SWOT analysis results** (compiled by the authors)*

Block 5. Formation of generalized quality assessments for consumer groups and in general in the educational direction. Generalized assessments are built on the basis of pairs of vectors for averaged linguistic assessments of the educational service and their average importance according to criteria from students, young professionals and employers: $A_1 = \left(a_1^1, a_2^1, ..., a_{n_1}^1\right)$, $W_1 = \left(w_1^1, w_2^1, ..., w_{n_1}^1\right)$, $A_2 = \left(a_1^2, a_2^2, ..., a_{n_2}^2\right)$, $W_2 = \left(w_1^2, w_2^2, ..., w_{n_2}^2\right)$, $A_3 = \left(a_1^3, a_2^3, ..., a_{n_3}^3\right)$, $W_3 = \left(w_1^3, w_2^3, ..., w_{n_3}^3\right)$.

Three linguistic variables are introduced Z_1, Z_2, Z_3 - integral assessments of the quality of educational services from the perspective of students, young professionals and employers, respectively, and the linguistic variable Z - a general integral assessment of the quality of educational services.

The term set of entered variables is $Y = \{H_1, H_2, ..., H_5\}$, H_1 - « very low quality service », H_2 - « low quality service », H_3 -« average quality of service », H_4 -« high quality services », H_5- « very high quality service ».

The values of the resulting integral linguistic variables are formed using the linguistic MAX-operator (LMAX)

$$LMAX_W(A) = \max_i \min\{w_i, a_i\} \tag{10}$$

or linguistic MIN operator (LMIN)

$$LMIN_W(A) = \min_i \max\{Neg(w_i), a_i\}, \tag{11}$$

where Neg − denial operation on a linguistic scale $H = \{H_i\}_{i=\overline{0,5}}$ ($Neg(H_i) = H_{5-i}$). For example, when using the linguistic MAX operator, we get the following integral variables:

$$Z_1 = \max_{i=1,n_1} \min\{w_i^1, a_i^1\} ; \quad Z_2 = \max_{i=1,n_2} \min\{w_i^2, a_i^2\} ; \quad Z_3 = \max_{i=1,n_3} \min\{w_i^3, a_i^3\} .$$

To obtain a general integral assessment of the quality of educational services, classical linguistic weighted multiplicative and additive convolutions (Borisov et al., 1982) are used, associated with the numerical vector of weights W characterizing the importance of information sources.

Conclusion

The quality of educational services has a significant impact on the efficiency of the labour market, therefore, information systems and technologies that implement the tools for obtaining, structuring and providing information on the quality of educational services to subjects of the educational market and the labour

market are relevant. This paper presents an information analytical system for assessing the quality of educational services from the perspective of the main consumer groups, based on fuzzy algorithms for managing the local monitoring process and evaluating the quality of educational services from the perspective of three consumer groups: students, young professionals and employers. A specialized technology has been implemented for organizing an Internet site for conducting a consumer survey of services and processing the results of the survey by using linguistic group assessment methods. The proposed technology is a modification of the SERVQUAL method. The use of a fuzzy approach significantly expands the possibilities of structuring and averaging group survey information.

Summary

This paper presents an information analytical system for assessing the quality of educational services from the perspective of the main consumer groups, based on fuzzy algorithms for managing the local monitoring process and evaluating the quality of educational services from the perspective of three consumer groups: students, young professionals and employers. The basis of the developed information analytical system is a linguistic algorithm aimed at the formation of the estimated characteristics of the quality of educational services. The algorithm is based on the SERVQUAL method, in accordance with which the score assessment of quality in the service sector should be based on the customer's comparison of his/her expectations of quality before consuming the service with the perception of quality at the time of its receipt. The information base, on the basis of which private and integrated estimates are formed, consists of specially developed questionnaires of students, young specialists and employers. Fuzzy linguistic information processing tools allow you to expand the range of tools for analysing the results of the survey, use a fuzzy inference machine that models the process of generating conclusions based on estimates of expectations, perception and importance for each item of the questionnaire of each group of respondents, build different strategies for aggregating group information.

In the process of working with the information analytical system, the researcher receives: a linguistic quality assessment from the position of each consumer for each evaluation criterion; a linguistic assessment of the quality and importance for each criterion of each group of consumers; integral linguistic assessments of the quality of each consumer group, an integral linguistic evaluation from the position of all consumers; on the basis of special logical rules, a matrix of SWOT-analysis to highlight strengths, weaknesses, opportunities and threats to the educational direction is formed. The results of the algorithm depend on: the specification of linguistic variables expectation, perception and importance for the evaluation criteria; the rules used for fuzzy inference; the chosen aggregation strategy embedded in the OWA aggregation operator when receiving a group assessment of the quality and importance of each criterion for each group of consumers.

It is intended to develop the algorithmic support of the information analytical system, which will allow the settings of the calculations (membership function of terms, group aggregation strategy) to be selected based on the analysis of the statistical distribution of survey data. In particular, it is planned to build confidence factors for high and low quality estimates obtained for individual respondents; also, when developing integrated estimates for each group of respondents, instead of LMAX and LMIN operators, it is planned to build special linguistic scales for translating quality values taking into account the importance of the criterion measured on a certain universal scale.

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