ANALYSIS OF DATA TO DETERMINE CUSTOMER LOYALTY IN THE EDUCATIONAL SPHERE USING KOHONEN MAPS

I. R. Gallyamova, N. I. Yusupova, O. N. Smetanina, L. Y. Uzbekova

Department of Computer Science and Robotics, Ufa State Aviation Technical University, Ufa, Russia

e-mail: g_irida@mail.ru, yussupova@ugatu.ac.ru, smoljushka@mail.ru, uzbekovalili@mail.ru

Abstract: This paper analyses the loyalty of consumers of the university services (i.e., university students). If students are not only interested in receiving a degree, but also proud of the university, recognizing their social responsibility for it, being ready to lead an active life within the university, then the university gets an advantage among its competitors. This study investigates the loyalty of students with regards to the USATU. The main method of investigation was a questionnaire for students. The results of the research can be used by universities when they offer their services on the market.

1. Introduction

The growing intensity of competition in the market of educational services, along with increasingmarket power of consumers in education make it necessary to develop a new model of identifying loyalty to the university from its direct consumers,the students.

In the field of educational services, just as in any sphere of the economy, it beneficial to study customer loyalty. However, unlike consumer loyalty in the economy, the region in question has a number of features that must be taken into account when speaking about the evaluation of the loyalty of university students. Consumers of educational services are constantly involved in the educational process and, in the final analysis, influence the activity of the university, processes in it, its image (reputation), etc. Formation of students' loyalty to the university is a multi-stage process, determined, first, by the terms of training; from course to course, loyalty can significantly differ. Constant updating of the student body does not allow talking about such a concept as "repeated services" (unless, of course, it is a question of additional educational services or additional (second higher) education) [2].

In the article, questions of the intelligent analysis of the collected personal data are considered. The results obtained should make it possible to identify the most significant factors influencing the loyalty of students, the nature of the answers to the questionnaire of students who have a similar level of satisfaction with the university, and therefore, to make decisions about increasing loyalty with the use of this knowledge.

The issues related to the term «loyalty», the formulation of the task of data processing and the formation of rules of logical inference for supporting decision-making, the data processing scenario are reflected in detail.

2. Related work

It is important to note that the study of customer loyalty, coming from foreign countries, is intended for trade and public consumer services. Studies in this area were pioneered by foreign scientists [5]. There are many viewpoints regarding the topic of loyalty, the most prominent of which are shown in Table 1.

Table 1. Comparison of existing definitions of the term «loyalty»

Definition of loyalty	Autor
«Regular (repeated) acquisition of a product of this brand, based on a long acquaintance with it and a favorable attitude towards it»	John R. Rossiter, Larry Percy [4]
«When a product is attractive to consumers in a degree sufficient to make a repeat purchase»	William D. Wells [5]
« A measure of consumer loyalty to the brand». In the opinion of David A. Aaker, loyalty shows the degree of probability for switching the consumer to another brand, especially when it is undergoing changes in price or some other indicators. With increasing loyalty, the tendency of consumers to perceive the actions of competitors decreases	David A. Aaker [6]
«Preferring one brand at every purchase of a product». Gordon R. Foxall notes that «the consumer follows the model of re-purchase, because it is this brand that satisfies his needs quite well, or because he has a personal attachment to the brand». In addition, «this brand provides all the desired benefits, corresponds to the lifestyle of the consumer or its character (image) is the same as the nature of the consumer»	Gordon R. Foxall [7]
«Devotion to your source of value». A loyal buyer does not change the source of values, that is, from time to time acquires a product or service, and recommends it to his environment	Frederick F. Reichheld [8]

The term loyalty means a positive attitude towards a product, service, or company, which manifests itself in a positive response (recommendations, reviews, etc.).

Researchers approach the problem from many different points of view. The problems of the management tools for the competitiveness of goods and services of the enterprise are devoted to the work of many domestic and foreign scientists and specialists. Among the researchers are, just to name a few: Ansoff [9], C.B. Barsukova, M.I. Gelvanovsky, A.L. Denisova, A.A. Dynkin, P.S. Zavyalov, T. Kono, V.M. Kudrov, Zh.Zh. Lamben, A. Marshall, G. Mintzberg, N.K. Moiseeva, V.V. Ovichinnikov, M. Porter, A. Strickland, N.V. Telnykh [10], J. Thomson, V. Feldman, P.A. Fathutdinov, I.P. Cherednichenko, and others.

The theoretical basis for control of relations with customers on the basis of loyalty programs, specifically the building of loyalty programs have been developed and analyzed in the works of these foreign researchers: D. Aaker, S. Brown, S. Butcher [12], N. Boodcock, R. Goldsmith, T. Goki, K. Gronroos, S. Coils, F. Reyheld, V. Sesser, G.Wollard, G.Foxhall, G. Hofmayer, G.L. Bagiyev, V.P. Lukin, Z.V. Kulikova, O.V. Firsanova,O.Y. Tsuvenskaya, I.P. Shirochenskaya.

A number of researchers [1] investigated the questions regarding loyalty among alumni, giving greater attention to increasing the quality of education and the reputation of the university, in order to increase funding and employment of graduates, because of a significant increase of the competition.

Considering the issues of the tools used to analyze data related to loyalty, either directly or indirectly, it should be noted:

– statistical tools for a hybrid model of interaction between alumni and the university, which allows us to assess the situation at a given

time and concentrate on factors that affect the loyalty of both students and alumni to the university – modeling structural equations [1],

– a toolkit in the form of a semantic analysis of bank customers' feedback to identify the key of the text, and as a result, calculation of the NPS index for the bank, comparing the dynamics of the index with the values of the indices of banks that are industry leaders in servicing small businesses [13]

– tools in the form of probabilistic-static models and methods to assess the quality of services based on the opinions of consumers [14], etc.

Despite a lot of attention being devoted by specialists to research, theoretical and practical methods of forming loyalty among customers, many of its aspects have not been sufficiently investigated until recently: the factors which form loyalty towards educational institutions have not been systematized, the criteria determining the degree of influence of the loyalty program on the attitude of students towards the university have not been investigated.

3. Data processing tasks for determining customer loyalty

The actual task is to analyze data to determine the loyalty of consumers of educational institutions with the subsequent development of the mechanism for its management.

To solve this problem, it is required to use data that is aimed at identifying students' satisfaction and develop means of processing that data to identify factors that have the greatest impact on students' loyalty, and possible clusters that combine questionnaires (learners) with similar answers to questions. The authors attempt to reveal what is common between those students who are most satisfied with the university.

There are two ways to obtain information for student loyalty research:

– develop a special questionnaire to identify factors that affect the loyalty of students and conduct a survey for a fairly large number of students;

– use the data from the questionnaire, conducted earlier to solve various analytical problems.

A survey of students at USATU is conducted regularly to address issues related to improving the quality of education [14]. The collected statistical material is used as data for solving various problems.

One of the questionnaires used by USATU experts from the Testing Center Rozanova L.F., Turutina A.D. and Markevich I.A. [14], is aimed at the study of the probabilistic-statistical model of consumers' opinions for the quality assurance system. It helps to identify the requirements of consumers, assess the degree of compliance of these requirements with the performance indicators of the organization.

The difference between the research of the specialists of the USATU testing center from the article conducted by the authors is that in the first case the model of multiple choice to the task of assessing the quality of the educational process from the point of view of trainees.

This article discusses students' loyalty to the university, related in addition to the 7 factors.

In the second case, these questionnaires will be used to determine the loyalty of consumers in the field of education, as well as to determine a list of specific recommendations aimed at increasing students' loyalty to the university.

Analysis of data to determine customer loyalty in the educational sphere in the article implies the solution of the following tasks considering the available statistical materials:

– definition of the technology for processing available statistical data – the results of the questionnaire;

– selection of adequate theoretical apparatus for data processing at each stage of the selected data processing technology;

– conduct data processing based on the chosen technology, taking into account theoretical tools with interpreting the results of students' loyalty.

4. Data processing technologies

Collection of data for analyzing the loyalty of students at the University is made on the basis of the students questionnaire results made earlier for solving other problems.

The questionnaire includes several questions that allow one to identify the impact of certain factors on the satisfaction of the university, among which are:

– quality of the educational process;
– further cooperation with the university;
– maintenance of educational process;
– extracurricular work with students;
– level of motivation;
– accessibility of information on the educational process;
– social work of the university.

The algorithm for processing the questionnaire data assumes the following sequence of steps. It should be noted that the first three steps constitute the preliminary preparation of data for their processing.

Step 1. Formation of an initial data set in the form of questionnaires presented in natural language, in the form of an Excel table and checking for the completeness and correctness of filling the fields.

Step 2. Forming the results of the questionnaire as a data set in the text format .csv, which is digitized with the regular expression [^ 0-9; \ n] as a function of replacing Notepad ++ with an empty cell to clear the text content.

Step 3. Introduction of an additional criterion for the level of loyalty for data processing. According to the selected factors, various sets of questions are compared with the answers and a scale is introduced for assessing the students' satisfaction from 1 to 100. Next, a rating assessment of the options for answering questions on students' satisfaction – from positive (100) to negative (1).

Graduation of the loyalty criterion from 1 to 4 is introduced depending on the satisfaction (1 – dissatisfied, 2 – partially satisfied, 3 – satisfied, 4 – absolutely satisfied). To each questionnaire is assigned the evaluation of expert opinion on student satisfaction, depending on the quantitative ratio of factors.

At this stage, the preliminary processing of the results of the questionnaire is completed and the data is ready for further analysis. To perform the data mining, the Deductor platform was chosen.

Step 4. Data validation is performed using the «Data Quality Assessment» handler to determine the degree of their suitability for solving the problem of student loyalty analysis. The fitness indicator is a value of 1. If the data is less than 1, then it is necessary to identify the cause of unfitness and outline ways to improve the quality of the data.

Step 5. Using methods of factor analysis on the preliminary prepared data of the questioning of students with the purpose of reducing the dimension.

Step 6. Correlation analysis to assess the dependence of the output data fields on input factors and eliminate insignificant factors. The principle of correlation analysis consists in the search for such

values, which are least correlated (interrelated) with the output. Such factors can be excluded from the resulting data set with practically no loss of useful information. The criterion for the decision to exclude is the threshold of significance. If the correlation (degree of interdependence) between the input and output factors is less than the significance threshold, then the corresponding factor is discarded as insignificant.

Step 7. Cluster analysis of the obtained normalized data using Kohonen maps. The card is based on the neural network of Kohonen, whose architecture is represented by two layers of neurons: input and output.

The mechanism of clustering using Kohonen self-organizing maps in the analytical platform Deductor is represented by the following: in accordance with the values of the input parameters (values of loyalty factors), the sampling element correlates with the corresponding cluster.

Self-organizing feature cards allow representing the results of clustering in the form of two-dimensional maps, where the distances between objects correspond to the distances between their vectors in a multidimensional space, and the characteristic values themselves are displayed in different colors and hues. So, the areas marked in red indicate a high value of the indicator, and the dark blue ones indicate the lowest value of the indicator.

Step 8. Analysis of the obtained clustering results using Kohonen maps for obtaining meaningful conclusions for the considered area of consumer loyalty in the educational sphere and the formation of logical inference rules.

5. Mathematical statement of a problem and theoretical frameworks of processing of data

Let $X=\{X_1, X_2, ..., X_m\}$ – a lot of the completed and processed questionnaires, where m is the number of such a questionnaire. Furthermore, each element from a lot of X_i is described vector of the features and additional criteria values:

$$X_i = \{x_{i1}, x_{i2}, ..., x_{in}, x_{in+1}\}, \tag{1}$$

where $x_{i1}, x_{i2}, ..., x_{in}$ – the details of the preferences of each student (n – number of the attributes); x_{in+1} – student evaluation i (i.e. results from the questionnaire survey).

Required:

– Get a vector of reduced dimension of features:

$$X_i' = \{x_{i1}, x_{i2}, ..., x_{il}\}, \tag{2}$$

where l – the number of elements of a vector of reduced dimension. For further processing using a set of X'.

– Identify clusters with $\cup\, Y_j = X'$, $j = \overline{1,c}$, where Y_j – cluster j, $0 \subset Y_j \subset X'$, $Y_i \cap Y_j = \varnothing, i \neq j$.

Thus, it is necessary to find a function $f'\colon X_i' \to Y_j$, which any element X_i' assigns the cluster number j.

– It is necessary to analyze the characteristics of each cluster, interpret the results obtained in accordance with the semantics of the field.

As an analysis tool, an analytical platform Deductor is used.

The algorithm for factor analysis of this platform is based on the principal component analysis (PCA).

For factor analysis, the initial matrix is used, which is transformed and the eigenvalues λ are calculated. If we consider this procedure from the point of view of geometric meaning, then we can say that in the original space the geometric axes are subjected to rotation. Thus, a new factor is introduced, created by each axis. Then for each factor it is necessary to calculate the value in the new feature

space. Due to the reduction in size, only new factors with high values will be left. PCA is based on the following formulas, where λ is the eigenvalue R; R – covariance matrix; V – the eigenvector R.

$$RV = \lambda V. \tag{3}$$

Then

$$RV - \lambda V = 0, \tag{4}$$

$$V(R - \lambda E) = 0. \tag{5}$$

And there is a solution when

$$|R - \lambda E| = 0, \tag{6}$$

where E is matrix unit.

Next, we need to find the determinant for the matrix of dimension, determine the vector V, insert eigenvalue (formula 5) and solve the corresponding systems of equations. The sum of the eigenvalues is equal to the number of variables, and the determinant of the correlation matrix is the product. The eigenvalue is the variance of the axis, the largest is the first and, finally, descent to the smallest value is the amount of information along the axis. The proportion of the variance for this component is as follows: it is necessary to divide the eigenvalue by the number m. The load factors for these components are calculated by dividing the eigenvectors by the square root of the corresponding eigenvalues.

For a complete analysis of data and factors, one should consider the Kohonen maps. The Kohonen map is a powerful self-learning mechanism for data clustering that displays results in the form of compact and two-dimensional maps for interpreting data.

The training sample for cluster analysis is selected

$$X'' \subset X'. \tag{7}$$

The yield is a set of clusters that include similar characteristics

$$Y = \{Y_1, Y_2, ..., Y_j\}. \tag{8}$$

Specified distance function between objects $\rho(X_i, X_j)$. It is required to break the training sample into clusters based on the similarity of the characteristics of the object for one cluster and the difference in the characteristics of objects of different clusters. In this case, each object $X_i \in X''$ is assigned a cluster number Y_j. Then each object belongs to one of the classes.

The solution of the problem using Kohonen's self-learning network is based on the fact that the neural network, guided by the structure of input vectors, connects the object to a certain class.

When developing the Kohonen network, the number of neurons at the input (in terms of the number of features of the object) and the output layer (the number of clusters), the learning rate η (by default 0.3) and the stopping criterion (the default error does not exceed 0.05) shall be defined.

When sending object attributes to the input, neurons in the output layer compete for the right to be a «winner». The incoming weights of the «winning» cell are closest to the input image (in the sense of the Euclidean distance). It can be noted that each output cell determines the «proximity» to the input image, and for the winning cell j', the relation $\forall\, j$ gives

$$|\omega_j - x| \leq |\omega - x|. \tag{9}$$

The winner has the right to regulate its weight in accordance with the following rule of weight change [15]: $\Delta\,\omega_{ij} = \eta \wedge (j, j')(x_j - \omega_{ij})$, where $\eta \wedge (j, j')$ – the neighborhood function, which is equal to unity for $j = j'$ and decreasing with distance $|r_{j'} - r_j|$ between neurons j u j' in the output layer.

The Kohonen network learning algorithm is determined by the following steps: weight initiation, setting of neighborhood function parameters and learning speed; computation $\forall\, j$

$$D(j) = \sum_i (\omega_{ij} - x_i)^2, \qquad (10)$$

where ω_{ij} shows synaptic weights between neurons i and j if the stopping rule is not executed.

The next step is to find such an index j', that $D(j') = min$, calculation for all cells j within a certain neighborhood from j' and $\forall\, i$ detecting

$$\omega_{ij}(n) = \omega_{ij}(o) + \eta \wedge (j, j')/x_i - \omega_{ij}(o)/, \qquad (11)$$

where $\omega_{ij}(n)$ and $\omega_{ij}(o)$ – new and old values of training sample weights, then the change in the speed of training. The next step is to reduce the radius of the neighborhood function; check the stop condition.

Thus, this section describes methods for analyzing students' assessments (reviews).

6. Results of experimental data processing

The questionnaire used by researchers contains 44 questions related to different aspects of the university. The student can choose one of the available answers from 3 to 10. Examples of questions are given in Figure 1.

Whether you are satisfied that you learn at this university and on the given direction of preparation (specialty)?
1: Perfectly satisfied
2: Partially satisfied
3: No
4: Not sure

Your opinion about your specialty has changed during the education?
1: Yes, for the better
2: Yes, changed for the worse, disappointed
3: It did not change what I expected, it is
4: Not sure

Do you imagine what you will do after graduation?
1: I'm going to work
2: I will continue my studies in the magistracy
3: I'm going to get additional education
4: I'm going to postgraduate school
5: I will open my business
6: I will go abroad
7: I will not work at all
8: I'm going to join the army
9: Not sure
10: Other

Figure 1. Examples of questions

It is important to note that the questionnaire form was not created specifically for this study but it's results were used.

Step 1. This study used 1405 forms filled out by students after checking their responses based on completeness. The results were put into an Excel table. A section of it can be seen in Figure 2.

Figure 2. Example of personal data for analysis

Step 2. Results of the questionnaire are stored in a .csv file for further processing (Figure 3).

Figure 3. Fragment of processed personal data

Step 3. For the succeeding data processing, there is a further criterion for loyalty which is the overall score. After relating questions to the given factors, a score is given out of 100 total marks. Every questionnaire is given an expert rating based on an expert opinion of how well the questions relate to the factors.

Figure 4 shows a section of the processed data.

Figure 4. Processed data for analysis

As a result of the introduction of the loyalty criterion, it was found that in this sample, there were none absolutely satisfied students. Students were split into groups 1 (satisfied), 2 (partly satisfied), 3 (unsatisfied).

In total, 38% of students fall into the class «Satisfied Students», 45% - in the «Partially Satisfied Students» class, and 17% - in the class «Dissatisfied Students», out of 1405 students interviewed.

Thus, during further analysis, 8 factors are taken into account – 7 allocated and the 8th – the loyalty characteristic, that is, a vector of higher dimension is used for analysis.

At this stage, the preliminary processing of the results of the questionnaire is completed and the data is ready for further analysis.

Step 4. When assessing the quality of survey results, the capabilities of the Deductor platform are used. Since the usability indicator is close to one, all the answers to questionnaires are suitable for carrying out factor analysis of data.

Step 5. Based on the results of the factor analysis, a set of data is established, which is included in the resulting set of factors (Figure 5).

Figure 5. Results of factor analysis

It is established that all factors have a value greater than 0.9. Thus, we can say that each factor is significant, and the set does not need to reduce the dimension in determining the loyalty of students.

The next stage is the study of a set of questions related to certain factors. Issues that did not play any role for this task were identified. Namely, when the set of questions was correlated with the identified factors, it turned out that the answers to two questions out of 44 did not in any way affect the results of the study of students' loyalty. Thus, the questions «Did you have classes in physical culture? How many semesters did they last?» and «In what form are physical education classes conducted?» are excluded from the subsequent processing of the data.

As a result, the questionnaire questions are grouped into blocks of relevant factors (Table 2).

Table 2. *The structure of the questionnaire «The identification of students' satisfaction with the university»*

Name of question block	Question number of the questionnaire
Quality of the educational process	4; 5; 9; 12; 15; 17; 25; 26; 27; 35
Further cooperation with the university	6; 7; 10; 11
Ensuring the educational process	16; 18; 19; 20; 21; 22; 32; 33; 44
Extracurricular work with students	23; 24; 28; 29; 34; 39; 40; 41; 42
Level of motivation	1; 2; 3; 8
Accessibility of information on the educational process	13; 14; 36
Social work of the university	37; 38; 43

Step 6. The results of the correlation analysis of the data from the survey answers show the degree of influence on the students' loyalty (Figure 6).

Figure 6. Results of correlation with output fields

Factors can be ordered by the degree of influence on the factor «student loyalty» in descending order:

1. accessibility of information on the educational process;
2. quality of the educational process;
3. ensuring the educational process;
4. extracurricular work with students;
5. level of motivation;
6. social work of the university;
7. further cooperation with the university.

The factor that has the greatest impact on students' loyalty is «Accessibility of information on the educational process». According to the results of the survey, it turned out that students do not reflect on further employment and consider the factor «Further cooperation with the university» as the least significant at the university. Perhaps this is due to the fact that the questionnaires were not subjected to graduate students.

A student at the level of training in the 1–3 courses is not yet aware of himself as a future representative of the real sector of the economy and does not yet think on this topic, as psychological attitudes are aimed at absorbing new information while studying at the university.

Step 7. Cluster analysis of data is carried out using the Kohonen map. The best result of cluster analysis is a breakdown into 7 clusters. Figure 7 shows a map of Kohonen for revealing the loyalty of consumers in the educational sphere.
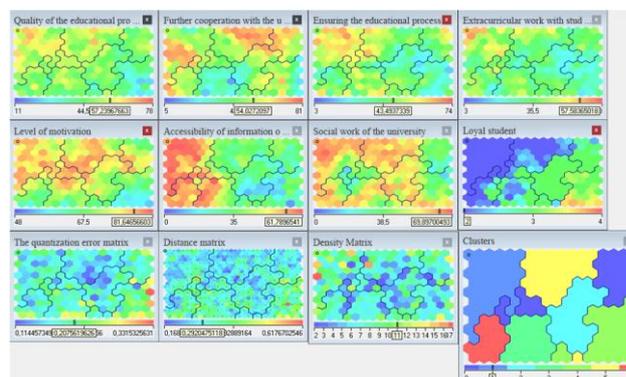

Figure 7. Results of cluster analysis

Cluster № 0 includes partially satisfied students, whose responses are characterized by below-average level of extracurricular work with students, average level of social work of the university, accessibility of information about the educational process, quality of the educational process and above the average level of motivation of students, ensuring the educational process and further cooperation with the university.

Cluster № 1 includes satisfied students, characterized by a high level of all the factors of loyalty.

Cluster № 2 includes partially satisfied students, characterized by a lower average level of access to information about the educational process, extracurricular work with students, providing the educational process, an average level of further cooperation with the university, quality of the educational process and above the average level of motivation of students and social work of the university.

Cluster № 3 includes partially satisfied students, characterized by a lower average level of further cooperation with the university, an average level of extracurricular work with students and a high level of other factors.

Cluster № 4 includes dissatisfied students, characterized by a low level of all factors, except for the social work of the university (middle level).

Cluster № 5 includes satisfied students, characterized by a high level of all loyalty factors, except access to information about the educational process (medium level).

Cluster № 6 includes partially satisfied students, characterized by low level of motivation, provision of educational process, secondary level of extracurricular work with students, quality of educational process and above average level of social work of the university, further cooperation with the university and high level of access to information about the educational process.

As a result of the cluster analysis on the values of factors from 1405 questionnaires, 20% of the students surveyed fall into cluster № 1, 18% into cluster № 5, 17% to cluster № 4, 15% to cluster № 2, 14% to cluster № 0, 9% to cluster № 3, and 7% to cluster № 6.

Step 8. In the process of reviewing the results of cluster analysis, a table is compiled in which the boundaries (minimum value and maximum value) of the factor in this cluster are reflected at the intersection of the columns (the received factor) and the rows (cluster number). Considering the results of the questionnaire, it is possible to identify which students entered each cluster. Further, by allocating each student and assigning them a cluster number, it is possible to analyze the values of the initial factors.

Based on the results of the cluster analysis (Figure 4), the boundary values of the factors in each cluster are revealed. Thus, as a result of the interpretation, students are identified in one or the other cluster. Table 3 shows the results of a cluster analysis with ordering by the degree of student satisfaction.

Table 3. Results of cluster analysis

	C1 (cluster 1)	C2 (cluster 5)	C3 (cluster 3)	C4 (cluster 0)	C5 (cluster 6)	C6 (cluster 2)	C7 (cluster 4)
Social work of the university	high level	high level	above the average level	the average level	above the average level	above the average level	the average level
Accessibility of information on the educational process	high level	the average level	high level	the average level	high level	below-average level	below-average level
Level of motivation	high level	high level	above the average level	above the average level	below-average level	above the average level	high level
Extracurricular work with students	above the average level	above the average level	the average level	below-average level	the average level	below-average level	below-average level
Ensuring the educational process	high level	high level	above the average level	above the average level	below-average level	below-average level	low level
Further cooperation with the university	above the average level	high level	below-average level	above the average level	above the average level	the average level	below-average level
Quality of the educational process	high level	above the average level	above the average level	the average level	the average level	the average level	below-average level
Student loyalty	Satisfied	Satisfied	Partially Satisfied	Partially Satisfied	Partially Satisfied	Partially Satisfied	Unsatisfied

To identify the loyalty of students, clusters are combined into classes. Clusters № 1 and 5 fall into the class of «Satisfied Students», clusters № 0, 2, 3, 6 fall into the class « Partially Satisfied Students» and cluster № 4 falls into the «Dissatisfied Students» class.

Based on the results of cluster analysis, it is possible to identify the reasons for students' dissatisfaction. In total, the main reasons for getting into the «Satisfied Students» class are those students who do not have low values of the factors. In the class of «Partially Satisfied Students» are low values of 1– 3 factors. In the class of «Dissatisfied students» are students who have noted low indicators of the values of all factors, or all but one of the factors.

7. Conclusion

Questions of research on customer loyalty are of fundamental importance in the improvement of university education. A review of known research in the field of consumer loyalty management has substantiated the urgency of researching issues related to the specifics of forming student loyalty in relation to universities.

The data processing technique for revealing student loyalty involves processing the results of the questionnaire using factorial, correlation and cluster analyzes based on Kohonen maps. The next stage is the development of rules for decision-making for the information support system for managing student loyalty.

As a result of processing data on student questionnaires, 7 factors were identified, among which the factor «Accessibility of information on the educational process» has the greatest impact on student loyalty, and the least influence is the factor «Further cooperation with the university». Additionally,nthe eighth factor, «Loyalty of the student» was highlighted, as some comprehensive assessment of the university's satisfaction.

According to the results of the cluster analysis of data on the values of the factors, 7 clusters were identified, later combined into three classes: «Satisfied Students», «Partially Satisfied Students», «Unsatisfied Students», and reasons for dissatisfaction of students were analyzed.

The offered approach for the analysis of the questionnaire data to reveal consumer loyalty in educational sphere assumes the need for further research and development.

References

1. N. I. Yusupova, O. N. Smetanina, and L. M. Iskhakova. "Models and methods of the processed in-formation in the Alumni management", Vestnik VGTU, vol. 8, no. 1, pp. 17-21, 2012. (in Russian)

2. Gallyamova I.R. "Information support for decision-making in the field of consumer loyalty management". Actual problems of science and technology: materials of the XI All-Russian Winter School-Seminar of students, graduate students and young scientists (with international participation), Ufa, USATU, vol. 1, pp. 51-54, 2018. (in Russian)

3. Smetanina O.N., Gallyamova I.R. "Information support of decision-making at management of loyalty with use artificial intelligence technologies". Problems of modern science and education. № 7 (127), Moscow, 2018. pp. 26-28. ISSN 2304–2338

4. John R. Rossiter, Larry Percy. "Advertising Communications & Promotion Management. Second edition". New York, N.Y.: McGraw-Hill, 1997. (Also, Japanese translation, 2000; Russian translation, 2001; Chinese translation, 2004).

5. William D. Wells, Sandra Moriarty, Nancy Mitchell, Charles Wood. "Advertising & IMC: Principles and Practice (11th Edition) (What's New in Marketing)", Pearson; 11th Edition, 2018.

6. David A. Aaker. "Building Strong Brands", Simon & Schuster UK, 2010.

7. Gordon R. Foxall, Ronald Earl Goldsmith, Stephen Brown. "Consumer Psychology for Marketing", Vol. 1, Cengage Learning EMEA, 1998.

8. Frederick F. Reichheld. "The Loyalty Effect: The Hidden Force Behind Growth, Profits, and Lasting Value", Harvard Business Review Press; Revised ed. edition, 2001.

9. H. Igor Ansoff. "Strategic Management", Springer, 2007.

10. Cherednichenko I. P. "Psychology of management", Rostov n/D: Feniks, 2004. (in Russian)

11. Jean-Jacques Lambin, Isabelle Schuiling. "Market-Driven Management: Strategic and Operational Marketing", Palgrave Macmillan; Third Edition, Revised edition, 2012.

12. Stephan A. Butscher "Customer Loyalty Programmes and Clubs (2nd Edition)", Routledge; 2nd Edition, 2016.

13. N. I. Yusupova, M. V. Chumakova "Semantic analysis of information for decision-making in the management of customer loyalty in the banking sector", Proceedings of the 5th All-Russian Conference «Information Technologies for Intelligent Decision-Making Support», Volume 1, May 16-19, Ufa, Russia, pp. 36-41, 2017.

14. Rozanova L.F., Turutina A.D., Markevich I.A. "The probabilistic-statistical model of consumers' opinions for the quality assurance system", Proceedings of the 3rd International Conference "Intelligent Technologies for Information Processing and Management" (ITIPM' 2015), Volume 2, November 10-12, Ufa, Russia, pp. 43-47, 2015.

15. Krichevsky M.L. "Intellegent methods in management", M.L. Krichevsky. SPb.: Piter, 2005 (in Russian).