IRMM
INTERNATIONAL REVIEW OF MANAGEMENT AND MARKETING
EJ EconJournals
ISSN: 2146-4405

International Review of Management and Marketing

ISSN: 2146-4405

available at http: www.econjournals.com

International Review of Management and Marketing, 2016, 6(S3) 200-209.

Special Issue for "Family, Education, Culture: Developmental and Management Characteristics of the Social Institutions and Processes Under Contemporary Conditions"

Innovative Methods in the Educational Processes of Contemporary Higher School

Evgeny Vasilyevich Shirshov[1]*, Tatyana Sergeevna Butorina[2], Valentina Nickolaevna Novikova[3], Churbanov Alexander Leonidovich[4]

[1]Northern Arctic Federal University, Embankment Northern Dvina 17, 163002 Arkhangelsk, Russia, [2]Northern Arctic Federal University, Embankment Northern Dvina 17, 163002 Arkhangelsk, Russia, [3]Northern Arctic Federal University, Embankment Northern Dvina 17, 163002 Arkhangelsk, Russia, [4]Northern Arctic Federal University, Embankment Northern Dvina 17, 163002 Arkhangelsk, Russia. *Email: Evgeny.v.shirshov@gmail.com

ABSTRACT

Based on the analysis of current trends in the development of higher education, upgrading the structure of curricula and teaching methods, experience of using information and communication technologies, some innovative methods of didactic software are discussed in the article. The systematic approach in the educational process of higher education, the justification of the composition, structure and patterns of major components of the educational activities, the creation of the necessary organizational and pedagogical conditions for the application of multicomponent technology implementation approach based on multivariate data analysis methods, and electronic information and educational technologies are of great importance in the study. In conclusion the article emphasizes that the main problem of this study was concentrated on applying mathematical and statistical tools in the field of humanities. In the context of a deeper understanding of the scientific and technological achievements justified and presented theoretical background for further development of future specialists training.

Keywords: Innovative Methods, Didactic Software, Educational Process, Polycomponent Approach, Artificial Neural Networks
JEL Classifications: I20, I25, I26

1. INTRODUCTION

The development of didactic software in educational process is based on the system approach therefore it is very significant to do research of the composition, structure and patterns of the major components in the educational process considering the changing of methods, ways, organizational forms and technologies of cognitive, subject practice-oriented activities in higher education institutions.

Social, economic and technological processes featured in the period of information technologies (IT) penetration, implementation of modern educational technologies, personal orientation cause some additional problems at the development of methodology for the application of scientific-pedagogical innovative methods. The methodology includes the rational ways of formalizing of pedagogical objects with the help of quantitative measurement of their functional characteristics and research methods of those models, which are constructed according to these principles.

2. METHODS

The results of psychological and educational studies on the issue made by the authors and the review of scientific publications (Anisimova, 2002; Volov, 2000; Leonova, 2005; Malyshev, 2006; Ostapenko, 2005; Sidorenko, 2007; Steinberg, 2000; Uvarov, 2008) show that at the stage of constructive solutions in the presence of explicit (latent) consistent patterns the necessity arises to use innovative methods for solving various problems of organization, control and prediction of the processes studied, including the educational processes.

As such, mathematical methods of data analysis are used. Multidimensional approach of data analysis is known to be rested on a wide range of statistic methods and evolutionary database modeling, that is, why within the frame of our investigation we confined ourselves only to those methods which are the best - of - bread solution for the base data as describing the real behavior of a cluster of objects, which allow us to estimate the reliability and accuracy of the conclusions reached in the course of experimental studies.

Multidimensional methods of analysis in psychological and educational studies include: Methods of mathematical statistics - multiple regression, correlation, discriminatory, factor and cluster analysis, principal component and multidimensional scaling; evolutionary modeling techniques - Genetic algorithms, artificial neural networks (ANN) (backpropagation, Kohonen's network etc.) (Nasledov, 2007).

The problem of multidimensional methods application in education and psychology has been studied in the works (Anisimova and Maslaka, 2002; Ermolaev, 2003; Grabar, 1977; Lebedeva, 2003; Mikheev, 2006). Thus, Anisimova considered the applying of multi-factors multivariate statistical analysis of experiments to assess the quality of studies and efficiency of a pedagogical innovation. Timkin (2007) conducted theoretical and experimental pilot studies on the introduction of distance learning technologies in the university educational process. Based on the application of factor and cluster analysis, he examined the results of the introduction of internet training in the traditional educational process. The author has obtained mathematized model, quantitative criteria and parameters of the quality of education. Onokov designing the system of "scientific support of new technologies effective use in professional training," applied multidimensional methods of correlation and regression analysis (Onokov, 2001). On the basis of data analysis Nehvyadovich proposed "regression model for anticipation of civil servants personal potential" (Nehveyadovich, 2006).

As the Russian scientist, Drozdova and Nasledov, pointed out at the English psychologist, Kettell, who got "professional portraits" for some specialities with the help of multiple regression analysis (Drozdova, 2007; Nasledov, 2007): Psychotherapist −0.72A + 0.29 B + 0.29 H + 0.29 N; psychodiagnost −0.31A + 0.78B + 0.47N, where Factor A - Readiness for contact, B - general intelligence, N - ability to maintain contact, H - Non-satiation of communicating with other people.

In the following equations, "regression ratios … indicate their contribution to the prediction of efficiency to related activities. Thus, for the psychotherapist the most important is socializing (a). And for psychodiagnost-intelligence (b). Along with "its predictions and its accuracy.," this method "allows to determine indicators ('independent variables') which are the most significant, important for prediction, and what variables can be neglected, excluded from the analysis" (Nasledov, 2007).

"The peculiarities of educational processes and phenomena, in Lebedeva's opinion, suggest the priority of meaningful - Humanitarian trending and demands the correct use of formal and logic means." She emphasizes that their reasonable combination "in the educational research is a serious scientific issue, because extreme formalization always causes the deprivation of essential part of the qualitative subject-matter, and its lack does not permit to discover it to the full" (Lebedeva, 2003). The application of mathematical means for analyzing of educational processes, in the author's opinion, is viable for investigating cognitive activity if its mechanisms are possible to elicit and put on paper.

The application of the formal-logical approach based on structural-qualitative analysis of the subject of research is largely determined by the nature of pedagogical phenomena and "…the influence of many hidden factors which are impossible to put on paper, much less due to their nature, associated with deep mental processes, students value orientations, mechanisms of realization of their cognitive activity" (Lebedeva, 2003). Therefore, considering the stochastic nature of social and pedagogical processes it is reasonable to envisage only probabilistic models of educational activity within the framework of this research.

3. RESULTS

In the course of one of the research stages while considering the technology implementation of didactic software in educational activity, the following significant factors were paid attention to: (1) Psychological factor (which characterizes the personality of a student) (the computer program "Sociological maintenance of educational process"); (2) evaluative (the results of acknowledgement tests of Unified State exams for school leavers and entrance exams to the university, substantive assessment on core subjects - History of pre-university education; IT assessments and other criteria done in the university; test scores in the disciplines of conformity rate etc., (Author's computer system testing and analyzing the results of "EOS" - The electronic training system).

As an experimental base used, the testing of students and listeners of all forms of education (full-time attendance, extra-mural courses, intra-extramural form of studies and others., all in all more than 120 people), of all courses and groups received for 6-year period at the time of admission to the university and graduation were used (completed list of factors is presented in Tables 1-6.

The students, whose qualifications are connected with finance, management (audit, accountancy, credit, economics of different branches, management of organizations etc.), that is, the students, who had rather high assessments when being admitted into the university, took part in the experiment. However, this does not diminish the importance of "school" factors, since this model can be applied to any group of students. Nevertheless, it should be borne in mind that the information content of the test data is defined by the variety of education levels of future specialists, and naturally depends on the results of schooling. The index of the regression equations in each case is necessary to clarify to more quickly adjust the status of students by level of education (clusters).

In the processing of survey results, questionnaires, testing specialized software (software product BaseGroup Labs

Table 1: Data of Kettell psychometric tests

Index	Denomination
A	Aloofness/sociability
B	Concrete/abstract thinking
C	Emotional instability/stability
E	Subordination/dominancy
F	Restraint/expressiveness
G	Low/high normalization of behavior
H	Shyness/courage
J	Realism/sensitiveness
L	Suspicion/gullibility
M	Pragmatism/stardust
N	Straightforwardness/shrewdness
O	Tranquility/anxiety
Q1	Conservatism/radicalism
Q2	Non-conformism (independence)/conformism
Q3	Low/high self-control
Q4	Emotional tension/unrestraint
MD	Low/high self-esteem
tkett	Time for test accomplishment

Table 2: Data of general certificate of secondary education, schooling results of state multiple - choice exams and assessment of admittance exams into university

Index	Variables
Att	Average score of certificate
salg	Algebra
sgeom	Geometry
sphiz	Physics
sinf	IT technology
codscool	Code of educational institutions (school, college, gymnasium, lyceum etc.,)
trus1	Russian language
tmath1	Mathematics
tin1	Foreign language
tmath2	Maths (USE-unified state exam)
trus2	Russian (USE)
tin	Foreign language
tgeog	Geography

- Deductor, Statistica Neural Network (SNN) of the Company StatSoft Russia, and programs of the Academy of IT technology "Sociological support of the educational process" as well as the author's computer system "EOS" were applied. The statistical analysis was performed by using the Universal Statistical Package, SPSS, which is Statistical Package for the Social Sciences).

All qualitative factors were checked for normality according to Pirson and Kolmogorova - Smirnova's criteria and in further researches, nonparametric methods of mathematic statistics were mostly used.

So the experiment with application of factor analysis (method of principal components and rotations) allowed to separate four significant input (derivative) factors, which define the students' academic progress in computer studies up to 80%. However, the content interpretation of these factors was not possible to achieve. The step-by-step discriminative analysis did not give any essential results either. The methods of cluster analysis (Euclidean, Mahalanobis, Hemming metrics etc.) proved to be "forceless", because clusters did not have definite bounds. The analysis of

Table 3: Ratings disciplines of relevant courses on traditional exams in high school and the results of tests (assessments) in other disciplines

Index	Disciplines
vmath, vinf	Maths, IT
vecon	Economics
vist, vphil	History, philosophy
vphiz	Physics
vpsih	Psychology and pedagogy
vin	Foreign language
vprav	Jurisprudence
vstat	Statistics
veconjrg	Organization economy
Index	Variables
de 10	% initial test right answers on paperwork management
bde10	Initial test on paperwork management
de11	% right answers in intermediate test on paperwork management
bde11	First test on paperwork management
del12	% right answers in final test on paperwork management
bde12	Final test on paperwork management
log0	% initial test right answers in logistics
blog0	Initial test in logistics
log1	% right answers in intermediate test in logistics
blog1	First intermediate test in logistics
log2	% right answers in final test in logistics
blog2	Final test in logistics
inov0	% initial test right answers IM
binov0	IM Initial test
inov1	% right answers in intermediate test IM
binov1	First intermediate test in IM
inov2	% right answers in final test IM
binov2	Final test IM

Table 4: Additional information

Index	Variables
edup	Father's education
edum	Mother's education
agep	Father's age
agem	Mother's age
birthday	Date of birth
ageday	Number of past days
month	Month of birth
pc	PC experience
csex	Gender numeric code

processing of research data was held on the basis of traditional methods and proved time-consuming.

Nevertheless, as the result of the analysis of matrix of Kendall and Spearman's rank correlation coefficient was pointed out the most significant and informative variables correlative with the results of standardized final test in computer studies. Moreover, the values of the Spearman rank correlation coefficient in most cases were much more than the correlative values of the Kendall rank correlation coefficient proving in favors of linear dependence between these variables.

Then, the step-by-step methods of multifactor linear regression helped to select a linear combination of factors that allow to take into account and make adjustments to the content and organization of the subsequent testing on "Computer studies" based on the

Table 5: IT technology assessments and other subjects studied in university

Index	Variables
inf0	% IT initial test right answers
binf0, binf3	IT Initial test, IT Final test
inf1	% right answers in first IT intermediate test
binf1	First IT intermediate test
inf2	% right answers in second IT intermediate test
binf2	Second IT intermediate test
inf3	% right answers in IT final test
tinf0	Time spent for IT initial test
tinf1	Time spent for first IT intermediate test
tinf2	Time spent for second IT intermediate test
tinf3	Time spent for final IT intermediate test
ite0	% initial test right answers ITE
bite0, bite3	ITE Initial test, ITE Final test
ite1	% right answers in first ITE intermediate test
bite1, bite2	ITE First intermediate test, ITE Second intermediate test
ite2	% right answers in second ITE intermediate test
ite3	% right answers in ITE final test
ise0	% ISE initial test right answers
bise0, bitu0	ISE Initial test, ITU Initial test
ise1	% right answers in first ISE intermediate test
bise1, bise2	First ISE intermediate test, Second ISE intermediate test
ise2	% right answers in second ISE intermediate test
ise3	% right answers in ISE final test
bise3	ISE Final test
itu0	% ITM initial test right answers
itu1	% right answers in first ITM intermediate test
bitu1	First ITM intermediate test
itu2	% right answers in second ITM intermediate test
bitu2	Second ITM intermediate test
itu3	% right answers in ITM final test
bitu3	ITM final test

Table 6: Additional information

Index	Variables
edup	Father's education
edum	Mother's education
agep	Father's age
agem	Mother's age
birthday	Date of birth
ageday	Number of past days
month	Month of birth
pc	PC experience
csex	Gender numeric code

All results are assessed on a five-point-grading scale. Abbr.: IM: Innovation management, IT: Information technology, ITE: Information technology in economics, ISE: Information systems in economics, ITM: Information technologies in management

data caused by the psychological factors and students educational backgrounds. In all variants of the formulas the unstandardized coefficients of variables were used in order to ensure a better visibility of the received results.

This set of significant factors was used to practical definition of students level at studying the discipline "informatics" ("computer studies"), which was selected as interdisciplinary in the process of students preparation for economic specializations.

The specification of the quantitative characteristics for determining the status of the first-year - students. The series are presented by the data about 191 students. With the help of the linear regression method, it became possible to allocate a combination of factors explaining the variation of the results succeeding test on "computer studies" test based on the Kettell test, the results of previous "computer studies" tests and school grade point average. The designations of variables are presented in Tables 7-11.

The second intermediate test on "computer studies":
binf2 = 0.379 − 0.0302binf0 + 0.0177inf1+ 0.229att + 0.0226H + 0.0374O − 0.343Q3 − 0.0141tkett + 0.00288agep

The Spearman rank correlation coefficient between the actual grades of the test and calculated by this formula is r = 0.622. It is reliable at the level of significance (alpha) = 0.01 that indicates a fairly close, direct and significant connection. The average value of the residuals (difference between actual and specified values for test) absolute value is (delta) = 0.326 points (on a five-point scale).

The final test on "computer studies":
binf3 = 3.736 + 0.0783binf0 + 0.026inf1 + 0.332binf2 – 0.07att + 0.0138vmath – 0.0343E – 0.0857J – 0.0593L – 0.0281F + 0.0168N + 0.0486MD – 0.347csex

The Spearman rank correlation coefficient between the actual grades for the test and calculated by this formula was r = 0.402. It is reliable at the level of significance (alpha) = 0, 01, that indicates average, direct and significant connection between these variables. The average value of the residuals absolute value (difference between actual and specified values for test) is (delta) = 0.442 points (on a five-point scale).

The results in the second formula are a bit worse in spite of more information about the students compared to the first one, and seemed paradoxical. Because the data are received during the educational process, and just the results of the final test define a "computer studies" grade, that is, why the final test has a special significance because its results may influence the expulsion of a student from university. Besides, some students get the final grade in the course of retaking's in this discipline. This circumstance makes the predictability worse but in the expanded DS (didactic system) "this kind of effects" will be absent because only successfully passed results of the test of the previous didactic unit electronic educational and methodical complex of discipline allow to come to studying material of the following block.

Personal factors that have a significant impact on the predicted results for the first-year - Students are in Table 7.

Obtained in such a way the complex of factors in the right-hand side of these equations can be used for practical first-year - Students subdivision into four groups depending on the results of their success in this discipline. Such a conditioned dividing is caused by the multilevel training, individual mental and psychological characteristics of students and necessity for the development of structured educational material in appropriate categories aiming at making the learning process easier for students. The student, whose received in the research assessment (binf) in the interval from 0 to 2, 5, is placed in the better group,

Table 7: Personal factors

Preliminary stage (binf2)	Accomplishing stage (binf3)
Shyness/courage (H)	Subordination/dominancy (E)
Tranquility/anxiety (O)	Realism/sensitiveness (J)
Low/high self-control Q3	Suspicion/gullibility (L)
Time for test accomplishment (tkett)	Restraint/expressiveness (F)
	Straightforwardness/shrewdness (N)
	Adequate/inadequate self-esteem (MD)

Table 8: Individual factors

Preliminary stage (binf2)	Accomplishing stage (binf3)
Adequate/inadequate self-esteem (MD)	Restraint/expressiveness (F)
Restraint/expressiveness (F)	Shyness/courage (H)
Shyness/courage (H)	Realism/sensitiveness (J)
Low/high normalization of behavior (G)	Time for test accomplishment (tkett)

Table 9: The main indicators, characterizing clusters, elicited as the results of the first experiment (1 course)

Indicators	Cluster			
	1	2	3	4
Minimum	52.0	32.0	48.0	52.0
Maximum	84.0	100.0	100.0	92.0
Average	67.0	65.6	65.4	66.6
Standard deviation	9.9	12.3	11.7	9.1

Table 10: The main indicators, characterizing clusters, elicited as the results of the second experiment (2 course)

Indicators	Cluster			
	1	2	3	4
Minimum	31.0	24.0	40.0	20.0
Maximum	100.0	100.0	92.0	100.0
Average	66.4	62.1	63.5	62.4
Standard deviation	14.3	17.4	14.2	15.6

Table 11: Comparison of "computer studies" calculated assessments based on different models with the list of Kettell's tests results

Surname, Name, Patronymic	Mark in computer studies (informatics)	Statistica (linear model)	Statistica (SNN)	Deductor
Antsiferova	4	3.40	4.10	4.00
Begunova	5	3.93	4.10	4.95
Belbaum	3	3.27	3.24	3.00
Bogdashova	4	3.64	3.24	4.00
Golovina	4	3.39	4.00	3.45
Dedova	3	3.35	2.95	3.00

SNN: Statistica Neural Network

level 1; from 2.5 to 3.5 - Group 2; from 3.5 to 4.5 - to Group 3; and more than 4, 5 - to Group 4.

In the second course, 191 students took part in the experiment. Out of whom 153 people were selected having all necessary for research data (variables). The same research methods were used to designate the linear combination of factors, which explained the variability of "Computer studies" succeeding test results based on the Kettell test data, the results of the previous tests and General Certificate of Secondary Education assessments.

The second intermediate test:

$$binf2 = 0.858 + 0.0883binf0 + 0.159binf1 + 0.378att - 0.236sgeom + 0.0895sphiz - 0.0445sinf - 0.0418MD + 0.0395F - 0.0178H - 0.018G + 0.0502edup + 0.0786edum$$

The coefficient of Spearmen's correlation between the actual grades of the test and calculated by this formula is: r = 0.528. It is reliable at the level of significance [alpha] = 0.001, that indicates a fairly close, direct and significant connection between these variables. The average value of the residuals absolute value (difference between actual and specified values of the test) is [delta] = 0.447 points (on a five-point scale).

The final test on "computer sciences":

$$binf3 = 1.787 + 0.1binf0 + 0.0385binf1 + 0.149binf2 - 0.0051tinf0 - 0.0701salg - 0.155sphiz + 0.158sinf + 0.0476F - 0.0351H + 0.0272J + 0.0526tkett + 0.485csex$$

The Spearman rank correlation coefficient between the actual grades of the test and calculated by this formula is r = 0.49. It is reliable at the level of significance [alpha] = 0.01, that indicates an average, direct and significant connection between these variables. The average value of the residuals (difference between actual and specified values for test) absolute value is [delta] = 0.472 points (on a five-point scale).

The analysis of the data shows that we noticed the deterioration of estimates in the final test with the second-year - students to adjust its content. The Kettell data are somewhat different, but it is natural, as sophomores have better skills for passing tests and this experience most characterizes their abilities. Thus, it is necessary to carry out psychometrics at least twice-after admittance and after their transition to the senior course. A certain characteristic, although weak, is the education of parents.

Individual factors, which have the significant influence on the predicted outcome for the second-year - students in Table 8.

The application of received dependences is analogous to the use of the correlative dependences in the first course.

The fourth-year - course is presented by the data about 267 students. Out of whom there is, unfortunately, the information only about 53 students having all the necessary variables. Applying the same scientific methods we succeed to designate the linear combination of factors, which explain the variability of the results of the succeeding test on the information systems in economics based on The Kettell test, the results of the previous tests and general certificate of secondary education assessments.

The final test on ISE:

$$bise3 = 0.909 + 0.0165ise0 + 0.0134ise1 + 0.0105ite1 + 0.21salg - 0.0748sinf - 0.0492F + 0.0421J + +0.0635L\ p$$

The Spearman rank correlation coefficient between the actual grades of the test and calculated by this formula was r = 0.68. It is reliable at the level of significance [alpha] = 0.01, that indicates a close, direct and significant connection between these variables. The average value of the residuals (difference between actual and specified values for test) absolute value is [delta] = 0.354 points (on a five-point scale).

The application of these formulas is analogous to the calculating of the correlative formulas for the first and second courses. Individual factors having the significant influence on the predicted outcome for the fourth-year - students: (1) restraint/expressiveness (F); (2) realism/sensitiveness (J); (3) suspicion/gullibility (L).

It should be noticed that the analysis of the received results of the research and survey of scientific publications on the point discussed (Burlachuk, 2002; Gorbunova and Lobachev, 2007) has proved that everything is not so simple. For instance, Burlachuk points out, it is interesting that out of all total factors only seven are "…found out in most scientific surveys about the personality structure …," that is: (1) Anxiety/emotional stability; (2) energy, activity/passivism; (3) self/assurance, persistence/submissiveness, susceptibility to influence; (4) strength of super-ago/weakness of super-ago; (5) autonomy/group dependence; (6) rationality, pragmatism/stardust; (7) impulsiveness/self-restraint, inner resources of character (Burlachuk, 2002).

Temkin "in the analysis of irregular conditions and traits that determine the success of the implementation process of the distance educational technology" has revealed, that "among student individual factors affecting successful implementation and assessment of learning outcomes, it can be assumed:… Social and biological (sex, age, course of study); individual ability to training regardless of the technology used; technological readiness (ready to use IT while studying); the attitude formed before the experiment to distance learning" (Timkin, 2007).

Thus, summing up the interim results it is necessary to emphasize that measurement of psychological factors is a difficult task. The main issue is the evaluation in humanitarian fields because the applied math and statistical means are apt for qualitative value measurement. Therefore, the results are indicative of the regression equation (exploration) character to select, for example, an individual learning path for each of the disciplines studied. Taking into consideration the complex of these equations, it can be argued that they do not express the fundamental laws of teaching, although, of course, reflect some aspects and the specific situation in the educational process of the university. In our opinion, the quantitative ratios obtained for different learning situations, can be used by teachers at the initial stage in the design of didactic structure of the educational process for the specific conditions in training (clarifying the content, choice of means, methods and organizational forms), i.e., in other words, to form a didactic vector based primarily on the development of the necessary professional competencies. On the other hand, a teacher should acquire the special knowledge, qualifications in the theory of mathematical statistics as well as possess the scope of social software, because the processing of data analysis is rather time –consuming process.

4. APPLICATION OF ANN

As the process of student preparation in universities depends on many factors, not enough formalized and investigated related to quantity, and the application of traditional statistic methods of data processing is rather time-consuming and not always justified, then the prospective lines for development in the tasks mentioned above, from our perspective, is the application of program - emulation ANN as one of the contemporary method of analysis in the education field.

Neural networks is "the class of analytical methods,… permitting to predict the values of some variables in new surveys according to the data from other surveys (for these or other variables) after fullfilling the so called phase of training on the available data" (Electronic Textbook on Statistics (2008) from http://www.stasogt.ru/home/textbook/default.htm).

Prospects for the use of ANN in the field of information processing, as well as problems of application of neural networking technologies and methods of artificial intelligence in pedagogy and psychology are represented by a large range of scientific publications (Golovko, 2001; Kruglov, 2001) and research works (Verbitsky, 2007; Kuvaldina, 2003).

The issues of realization of psychological model of the first-year - student's readiness for learning in universities, conception projecting of components of training methodical system to computer using automated methods based on artificial device networks are reflected in the works by Arzamastseva, Zenkova, Kitayevskaya. Since the results of the investigated Zenkova (2003) showed that for defining the preparedness of individuals enrolled in a number of specialties in high school (physical - mathematic and information), the most significant are - aptness for thinking, motivation, willingness and readiness training in this specialty.

According to Evstigneev and Pyatkovsky, in solving the subdivision problems for a given group ("level of knowledge, training and practical skills, the ability to analyze complex situations, the ability to creative thinking, initiativity, responsibility,… and other indicators of psycho-diagnostics") it is advisable to use the Kohonen self-organizing maps for visual display of "a group of graduates with the specified characteristics, as well as areas of possible risks and benefits, for example, when enterprise managers take decision about their job employment" (Evstigneev et al., 2003).

As Osovsky believes, being performed by neural network "functions can be divided into several main groups: The approximation and interpolation; recognition and classification of images, the compressed data; forecasting; identification; management; association" (Osovsky, 2002).

Based on these assumptions, we use for solving the task one of the most common and accessible understanding of multidimensional data analysis methods - the method of cluster analysis.

Cluster analysis (Eng. – cluster – group, cumulation) - "A broad class of multivariate statistical analysis procedures that allow to produce automated grouping observations into homogenous groups - cluster classes" (from http://www.slovari.yandex.ru/dict). Cluster is "a set of homogeneous elements, identical objects, forming a group of units" (Raizberg, 2007). So, for example, "in psychodiagnostic the cluster analysis allows to define the groups of examinees who possess similar psychodiagnostic profiles (correspondence between revealed and measured psychological attributes). The projecting of test cluster analysis allows you to group related test points (tasks) and, thus, double-check the results of another method of designing of factor scales - the results of the factor analysis" (from http://www.slovari.yandex.ru/dict).

The overview and analysis of the publications made in the context of the research problem has shown that the method of cluster analysis is used to justify the theoretical positions in dissertations and monographs, quite convincingly proves the feasibility of this method in the scientific-pedagogical practice. For example, Safontseva notes that "the cluster method is used in the expert evaluation of the content due to educational elements importance and the selection of a cell structure of the curriculum, the formation of the working field of project activities in the educational space on the basis of the degree of relationship between the structural elements, building the path for specialist professional training adjusted to the analysis of the configuration of the working field of the project activity, the selection of materials for didactic materials for educational activity, expert selection criteria indicators,… selection of plank jobs using a representative sample" (Self-organizing Maps - Mathematical Apparatus (2000) from http://www.basegroup.ru/neural/).

In our opinion, the polycomponent approach with the application of the cluster analysis and the use of ANN, allow to operationalize significant resources and opportunities of didactic software for designing and optimization of the university educational process, the implementation of modern tools, methods and organizational forms of learning associated with the use of electronic information and educational technology. For instance, if the input of the Kohonen network (a form of ANN) to submit data on psychometrics and the history of education, in the output we can get the number of the group (cluster), which the student in the discipline should belong to. Thus, we will be able to adjust the content of appropriate teaching materials, make a choice of means, methods and organizational forms for providing optimal learning conditions or identification of the factors, which affect the results, similar to the above-mentioned method, which is based on using traditional statistical methods of processing and analyzing data neural networks have well proven themselves in the solution of complex problems in medical diagnosing, financial management in the stock markets and many other difficult to formalize problems. "The complex of tasks which are possible to solve with the help of the neural network is defined by the way of how the network works and by how it is learnt" (Epstein, 2003). The best opportunities for these scientific tasks, in our opinion, belong to Kohonen's networks (network without a teacher, SOK (the self-organizing cards) and method K - average) and multilayer perceptron (network with a teacher). Both kinds of neural networks were applied within the frameworks of this research.

Kohonen's networks. "Kohonen's idea about networks appeared analogous to some properties of human brain. While all the other networks are apt for the tasks with supervised learning, Kohonen's networks are mainly considered for guideless one" (Epstein, 2003). As the opportunities of these methods are well-known, we are not going to discuss it in detail, and give the example of real use in the experimental part of the given research.

Basic data. The initial data for training ANN were the results of psychophysical test (Kettel's test) among the students for the six-year -period of studies.

Depending on the variant of those answers out of the 105 questions, each student who passed the test gained an appropriate sum of the numerical ratings. On the basis of these data in accordance with the known method (Kapustina, 2007), the numerical evaluation of 17 psychographic factors were obtained. All the data were processed by using a special module written in excel program.

The quantitative values of these factors were the basis for the training of an ANN. "The neural networks are inherently universal approximators and allow to model complex regularities which, for example, are not available the classical regression model" (from http://www.basgroup.ru/library/methodology/ontology). In addition, the training set included data on the students' performance in various subjects, a previous study, marital status, etc. analogous to the data used in the statistical method.

As an ANN the Kohonen networks are used, because they were proved to be the best suited for solving multifactor nonlinear analysis as our method have appeared good for the exploration analysis of similar quality of apriori data (Saphontseva, 2006; Uvarv, 2008).

It is possible to get the information about the Kohonen networks mathematical apparatus technique, its structure, the algorithm of realization and application on a web site Basegroup.

This method permits to evaluate the students' distribution in accordance with their characteristics. For this purpose in the experiment the input of the neural network was presented by the results of Kettel's psychographical testing, primary and intermediate tests on "Computer science," "Informatics," the average score in school diploma, the time of the Kettel's test passing and a number of other indicators for the first - and second-year students (185 and 167 records, respectively). When configuring lines with empty values on either factor in the training, the neural network was not used, since this would lead to a distortion model.

Neural network training. At the initial stage of training the software packages "Deductor and Statistica Neutral Network" of the company "StatSoft Russia" were applied. The choice of these packages is defined by the availability of the module "master of training" and the possibility of constructing the tree

dendrograms, what makes significantly easier with these tools at the trial experiment data analysis.

Analysis of the results. The required number of clusters allocated to the map was determined as a result of preliminary hierarchical cluster analysis. The more detailed description of the algorithm for solving this type of problem is presented on the company website StatSoft Russia.

In the course of the research, the dendrograms were obtained where three or five line branches of the tree are clearly seen united at the same height that corresponds to the desired number of clusters.

At the next step, it was necessary to find out which object (complex of investigated parameters for each student) belongs to this or that cluster field. As a result, with the help of "master of training" of the neural network Deductor some Kohonen's self-organized maps were built. The subdivision of map surface into clusters enabled us to group the first - and second - year - students. Aiming at making the information more visual, Kohonen's maps were plotted with the students surnames points (each point is represented the general characteristic of evaluated factors), those who had the approximately similar psychometric parameters and marks on "Computer science" falling into different cluster groups.

For the quantitative evaluation of parameters, the statistical indicators characterizing each separate cluster were rated. The average score on the final test on "Computer studies" for each cluster is different proving by the experiment results that there is dependence between the student performance and his psychographic characteristics (Tables 9 and 10).

With the purpose of comparison of the results obtained in the earlier experiment, we used a multi-layered perceptron. This type of ANN is more difficult to master; nevertheless, its application is stipulated by the greater capacity for solving nonlinear regression problems (Epstein, 2003).

Multilayer perceptron. In 1986 Rumelhart developed the network architecture - multilayer perceptron, in which for training of neural network "back-propagation algorithm" was offered (Electronic textbook on statistics: Section "Neural Networks" from http://www.stasogt.ru/home/textbook/default.htm).

This type of network is characterized by "...such elements which are organized in layer wise topology with straightforward of transmitting of signal. This kind of network can easily be interpreted as a model of input - output, in which weights and threshold values (shifts) are considered as free parameters of the model. This network may model the function of practically any degree of complexity, and the number of layers and elements in each layer defines the complexity of the function" (Electronic textbook on statistics: Section "Neural Networks" from http://www.stasogt.ru/home/textbook/default.htm).

The neural network training was carried out in two stages with the help of the software Deductor of the company Basegroup:

1. Module loading "master of training" INS (ANN)
2. Isolation of database fields that will be input to INS and target fields that will serve the benchmark for comparison with the output of the network
3. Selection of the algorithm Back Propagation as a learning algorithm of the multilayer perceptron, which distributes the error signals from the outputs of the neural network to its inputs in the direction opposite to the direct spread of the signals for the corresponding adjustment of the weights
4. Configuration of the neural network
5. Defining of the criteria at fulfilling of which the neural network training will be stopped
6. General description of all the parameters of the system for the preliminary control
7. The training of the neural network from the data based on the previously defined parameters.

5. DISCUSSION

The calculated data (Tables 11 and 12) with the results of the average score of the certificate, the initial test on "computer studies" treated with the help of multivariate methods of statistical analysis and neural networks (perceptron and Kohonen's self-organizing maps) and assessments of students in the final test "computer studies" taking into account Kohonen's tests.

The application of INS with the architecture multilayer perceptron showed a high correlation of the calculated values with the actual ones (p_1=0.724 for 1 course and p_2 = 0.7113 for 2d course) than the linear model, and less remnants in average (Δ_1 = 0, 182 for 1 course and Δ_2 = 0, 256 for 2d course).

The recognition accuracy of the training set was in the case of linear regression model - 58.39% (Statistica, linear model); neural network respectively - 82.67% (Deductor) and 83.92% SNN, which considerably exceed the indicators achieved as a result of building the linear regression model.

In the number of cases while making the experiments, the traditional statistical method (linear model) showed the higher correlation between the calculated and real results than Kohonen's network. However, this result is impossible to consider the final one, as the achieved data were singular, preliminary and demanded cumbersome calculations and carrying out some additional empirical experimental works, which we spoke in our materials before.

Nevertheless, the analysis of native and foreign psychological and pedagogical literature (Grabar, 1977; Ermolaev, 2003; Nasledov,

Table 12: Results of Kettell's test and informatics (fragment)

Surname, name, patronymic	MD	A	Mark in informatics	Linear model	Neural network
Antsiferova	6	11	4	3.40	4.00
Begunova	7	6		3.93	4.95
Belbaum	5	6	3	3.27	3.00
Bogdashova	7	7	4	3.64	4.00
Golovina	6	4	4	3.39	3.45
Dedova	5	8	3	3.35	3.00

2007; Sidorenko, 2007) and others specifies positive trends in the development of this current scientific approach.

In our opinion, the extensive experience of students' assessment in the academic progress based on psychometric tests and school achievements acquired in Israel, where the application of test systems and Common National Examination has a long history. The results of researches made by Epshein and Libin prove that "the psychometric test assessment allows to predict future students' achievements much better than their average score in Common National Exams in school. However, the more optimal way for predicting students' achievements is the combination of the psychometric test assessment and the average score in Common National Exams taken together" (Epstein, 2003).

In the context of the issue discussed, the attention is paid to the research made by Muromtsev connected with the realization of the conception of student - orientations. The author solves the task "students' clustering" on the basis of test application which enables "to put the definite student into the definite cluster in accordance with his preparation level and his peculiarities of digesting the material." In the identification algorithm of the student's preparation level "the methods of artificial intellect are used, including fuzzy tests, taking decisions on conditions of uncertainty etc.," (from http://ito.edu.ru.2007/Moscow/VIII/VIII-o-7483.html).

Thus, the choice of necessary software products and methods for the multifaceted data analysis, taking into account the feature of the original sets of tasks and complexity of the experimental work results processing is stipulated by the specific goals and objectives of pedagogical research.

As the analysis of the results of our scientific work shows, the most appropriate method of multifaceted data analysis, with respect to the set of tasks posed, is the cluster analysis, which is implemented on the basis of the apparatus of ANN.

6. CONCLUSION

In the conclusion it should be noted that formalization, qualitative methods and mathematical models applied in psychology and pedagogy to the full conduce the development of theoretical foundations of research, and its results may be recommended to high school teachers for application (especially these days while IT technologies penetrate the society, while processing and analyzing the vast quantity of different information) aiming at preliminary diagnostics of the students preparation (exploratory data analysis), content development of curricula and individual trajectory of a student training, the choice of means and methods, organizational forms and educational technologies for the qualifying of future specialists.

It is worth emphasizing that in both theory and practice the urgent development of contemporary organization of educational process in high school includes the active use of information and educational technologies based on electronic means of training and data analysis. First of all, for the solution of these research tasks in the respect of the society informatisation, the developing conception of the didactic software applied in the high school educational process makes the advancement of education prominent in connection to social and economic, communicative achievements, and, primarily, the success of postindustrial epoch of the humanity in the technological innovation.

REFERENCES

Anisimova, T.S., Maslaka, A.A. (2002), The Application of the Modern Theory of the Experiment in Education (Multifaceted Multivariate Experiment in Education). Moscow: RCPQTE.

Burlachuk, L.F. (2002), Psychodyagnostic. St. Petersburg: Peter.

Drozdova, N.V. (2007), Competence-Based Approach as a New Paradigm of Student – Oriented Education. Minsk: RIVSH.

Electronic Textbook on Statistics: Section Neural Networks. (2001). Moscow: Stat Soft. Available from: http://www.stasogt.ru/home/textbook/default.htm. [Last accessed on 2016 Jan].

Epstein, A.D. (2003), Pros and cons of Unified State test of applicants: Israel experience. Open Education, 5, 61-63.

Ermolaev, O.Y. (2003), Mathematical Statistics for Psychologists. Moscow: PSI, Flinta.

Evstigneev, V.V. (2003), Analytical Information System of Marketing of Educational Services in High School. SB. TR User Scientific Practice Conference Information and Communicative Technologies in High School Management. Petrozavodsk.

Golovko, V.A. (2001), Neural Networks: Training, Organization and Application. Moscow: IPRZHR.

Grabar, M.I. (1977), Application of Mathematical Statistics in Educational Research: Non-Parametric Methods. Moscow: Pedagogika.

Kapustina, A.N. (2007), In: Kettell, R., editor. Multifactor Personal Technique. St. Petersburg: Speech.

Kruglov, V.V. (2001), Artificial neural networks. Theory and Practice. Moscow: Hot Line - Telecom.

Kuvaldina, T.A. (2003), Systematization of the Concepts of Computer Science Course Based on Artificial Intelligence Methods: Doctor of pedagogical Sciences: 13.00.02. Moscow.

Lebedeva, I.P. (2003), Mathematical Modelling in Pedagogical Research: Monograph. St. Petersburg: Perm.

Leonova, N.M. (2005), Clustering of students as result of adaptive electronic educational resources in the learning process. Open Education, 4, 33-38.

Malyshev, C.B. (2006), Multifaceted Typological Approach to Obtain Information About the Subjects of the Educational Activity: The Dissertation of the Doctor of Psychological Sciences: 19. 00. 07. Samara.

Mikheev, V.I. (2006), Modeling and Methods in Theory of Pedagogy. Moscow: KomKniga.

Nasledov, A.D. (2007), Mathematical Methods of Psychological Research. Analysis and Interpretation of Data. St. Petersburg: Speech.

Nehveyadovich, A.D. (2006), Organizational -Pedagogical System of Effective use of New Information and Communication Technologies in Vocational Retraining and Advanced Training of Civil Servants: The Dissertation of Pedagogical Sciences: 13.00.08. St. Petersburg, 2006.

Onokov, I.V. (2001). Scientific System to Ensure the Effective use of New Information Technologies in Vocational Training: A Case Study of Technical Colleges: The Dissertation of Pedagogical Sciences: 13.00.08. St. Petersburg.

Organization of Distance Learning in High School. (2007), In: Gorbunovaet, E.I., Lobachev, S.L., editors. Theory and Practice: A Monograph. Mines: SRSUES.

Osovsky, S. (2002), Neural Networks for Information Processing. Moscow: Finance and Statistics.
Ostapenko, A.A. (2005), Modeling of Multidimensional Educational Reality: The Dissertation of Pedagogical Sciences: 13.00.01. Krasnodar.
Raizberg, B.A. (2007), Modern Economic Dictionary. Moscow: Infra.
Saphontseva, N.Y. (2006), Cluster Method of Projecting Pedagogical Objects. Rostov-on-Don: Rostov University.
Self-Organizing Maps - Mathematical Apparatus. (2000). Moscow: BaseGroup, Section Neural Networks. Available from: http://www.basegroup.ru/neural. [Last accessed on 2016 Jan].
Sidorenko, E.V. (2007), Methods Mathematical Processing in Psychology. St. Petersburg: Speech.
Steinberg, V.E. (2000), Theoretical and Methodological Bases of Multidimensional Teaching Tools for Learning Technologies: The Dissertation of Pedagogical Sciences: 13.00.01. Ufa.
Timkin, S.L. (2007), Pedagogical University System in the Context of Implementing Distance Educational Technologies: Monograph. Omsk: OmGU Publishing.
Uvarov, A.Y. (2008), Cluster Model of High School Changing Under Conditions of Informatization of Education. Moscow: MIOO.
Verbitsky, A.A. (2007), The use of neural networks in the problem of testing. Information Technologies, 9, 21-26.
Volov, V.T. (2000). System - Cluster Theory and Technology to Improve the Quality of Distance Education in High School: Dissertation of ProfNinja in Pedagogical Sciences: 13.00.01. Kazan.
Zenkova, N.A. (2003), Psychological Model of Students' Preparation of the First Course for Learning in High School: Dissertation of Associate ProfNinja in Psychological Sciences: 19.00.07. Tambov.