European Proceedings of
Social and Behavioural Sciences
EpSBS

www.europeanproceedings.com
e-ISSN: 2357-1330

DOI: 10.15405/epsbs.2020.03.02.19

CSIS 2019

11th International Scientific and Theoretical Conference "Communicative Strategies of Information Society"

SUBSTANTIATION OF STUDENTS EDUCATIONAL ROUTES UNDER CONDITIONS OF NEW SCHOOLING FORMATS

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Abstract

The article presents the results of a study devoted to the development of methodology and methods of modeling school students' educational routes. Generated analysis of regional educational systems development shows that realized at present new forms of interaction between schools and universities, Russian Academy of Sciences, network learning actualizes searches of new approaches to individualization of education and students' educational routes designing. It has been shown that since modern school education is carried out in an integrated regional space of project and research activities, it is necessary to conduct study of this process using traditional pedagogical, management and mathematical methods. As the main means of educational routes modeling, Saaty method of hierarchy's analysis was used. It allows to select an optimal educational route among possible alternatives and on this basis to make substantiated pedagogical and managerial decisions. The following alternatives (types of learning trajectories) were taken into consideration: school-elective (optional courses), supplementary education at school, school-university, school-Russian Academy of Sciences, network training. For the purpose of the model building the following criteria were selected: students' readiness, motivation for success, awareness of students about the opportunity to receive supplementary education, goal setting (or internal activity plan), willingness of the teachers. Numerical simulation carried out demonstrates that selecting among pedagogical alternatives for achieving optimal educational outcomes require considering of internal and external factors, establishing their relationship, justification of the preferred paths based on the evaluation of alternatives, identifying the influence of external factors on the process of selection an educational route.

Keywords: Educational route, Analytic Hierarchy Process, decision-making in education, internal and external factors of educational outputs.

https://doi.org/10.15405/epsbs.2020.03.02.19
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eISSN: 2357-1330

1. Introduction

At present educational systems at various levels (school, municipal and regional) are developing in new formats. Callings to improve education quality caused an increase of education system subjects. Centers for gifted children, improving schools and basic Russian Academy of Sciences schools were established and started their activities in short terms (Yarkova, 2009). The activity of supplementary education organizations is also changing: they interact with secondary schools in the organization of school students project activities in various forms: conferences, festivals, tournaments, competitions. The network organization of learning and education of schoolchildren becomes necessary, federal and regional programs of psycho-pedagogical and social-pedagogical support and guidance of gifted children, early vocational guidance of schoolchildren are carried out (Pryazhnikov, Rumyantseva, Sokolova, & Bakhtigulova, 2018).

It can be stated that there are prerequisites for school children to receive quality education. However, in order for these prerequisites to develop into significant factors providing the advancement of each student in learning and his education outputs, it is necessary to substantiate his individual educational route. Although the implementation of individual educational routs is determined in the law "On education in Russian Federation", Federal State education standards for primary general and basic general education and in schooling practice, the importance of this subject matter for educational theory and practice grows. It is due to the following reasons: formation of a regional educational space new quality, an increasing of its subjects' number. Hence, new opportunities for improving the material base and staffing for not only advanced training, but also project and research activities of students are developing (Curtis, 2002).

The conditions described above require new methodology and methods searches and justifications of new management and pedagogical decisions, interdisciplinary research, taking into account the importance of fruitful individual educational routes, selected among various possible alternatives, taking into account changes, forming in the regional education system. To make a correct (giving the most favorable educational result) decision in the influence of a variety of factors that affect the result, it is necessary to consider and choose relevant alternatives. For this purpose, additionally to traditional pedagogical methods, it is necessary to use modern school management technologies and mathematical methods (Sorokoletov & Solodova, 2015).

While education route selection the internal factors associated with individual characteristics of students have a leading significance: readiness to select, defining the purpose of the selection, the motives related to the preparation for independent living and self-awareness of students about opportunities for supplementary education. These factors acquire a personal meaning for students and become effective when the development of new activities, obtaining new knowledge help them to understand the possibility of their transformation and application in educational, educational-project and social-project situations.

At the same time, the system of modern education is significantly focused on the criteria of performance, competencies development, including professional, formation of students' skills of mobility, flexibility, social adaptability, stress resistance - both in social and professional environments (Asbjornsen, 2015).

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That's why modern approaches to education require not only a reassessment of the goals and objectives school educational programs, but also the transformation of the structure and methods of the educational process management.

One of the modern approaches in management is process-based. According to it any activity can be considered as a continuous series of interrelated processes, each of which, on the one hand, has a certain degree of autonomy, on the other - contributes to the final result (Lyubchenko & Karpova, 2012). This approach is actively used in the management of commercial organizations, but in the management of educational institutions, it has not yet found proper application.

More generally accepted in management is a functional approach, which does not provide the necessary flexibility and is not focused on performance in terms of building an individual educational and professional routes, with mastering not only the results of the educational process, but also the use of opportunities for transition to educational and professional activities that implement professional and personal aspirations of students.

The individual educational route as a specific way of students' personal potential realization assumes passing of a number of processes (the basic, supplementary education, optional courses, extracurricular activity, etc.). The processes can be carried out within the educational organization or its structural subdivisions, and beyond, with a focus on the final result – mastery actual competencies and skills as defined by State educational standards and select their own individual educational route (Dukanich & Korobeynikova, 2013).

The formation of an individual educational route is influenced not only by the main processes associated with the provision of educational services in accordance with the State educational standard, but also by auxiliary ones – psychological and pedagogical support of students, social and pedagogical support and organizational and pedagogical support.

These processes may be external to the educational organization, creating the need for tutor support of learning and require the expansion of the practice of process – based approach to the management of students' educational routes in new formats of education.

The selection of educational routes depends both on individual students' characteristics and on external factors. Thus, in our study we have identified two groups: individual characteristics affecting the choice of learning and educational routes (internal factors), and tutors support of this process (external factors).

Educational outputs of the route, chosen for each student evaluation is carried out in the learning process. Therefore, an improper choice of the pedagogical decision can lead to poor learning and educational outcomes. In this regard, it is necessary at the initial stage to develop a methodology and methods for choosing a route of training way, depending on the selected criteria. Analytic Hierarchy Process (AHP) allows to design recommendations for the selection among possible alternatives (Saaty, 1980).

2. Problem Statement

The problem of the research is to identify the factors of pedagogical decision-making about educational route selection for school students, based on the evaluation of possible alternatives.

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3. Research Questions

Research tasks:

- Identify groups of internal and external factors of educational routes selection/
- Establish the relationship of the identified groups of the factors.
- Design recommendations for determination preferred educational routes with help of AHP.
- Disclose the influence of the external factors on the process of the educational route.

4. Purpose of the Study

The purpose of this study is to substantiate the methodology and methods of detection the factors influencing the selectoin of an appropriate individual educational route, based on the alternatives evaluation.

5. Research Methods

To make the adequate decision under the influence of a variety of the factors affecting the result, it is necessary to consider and select the most fruitful alternative. One of the mathematical methods of processing alternatives is the method of Saaty - AHP. This method is used to solve multicriteria problems with hierarchical structures, including both quantitative and qualitative factors (Saaty, 2008).

At the first stage of the study psychological and pedagogical research methods were used, students, teachers and management personnel in different fields of education were studied. Based on the results of the first stage research the criteria, necessary to build a hierarchical model, were identified as well as the forces that affect the organization and learning according to individual educational routes. While selecting the criteria, the results of previous studies on the problems of school students project activities organization were used, such as the readiness of students for additional education, motivation for success, goal-setting (Kagakina, Lesnikova, Rusakova, & Timoshenkova, 2018)

At the second stage of the study, a hierarchical model of selecting an individual educational route was constructed. At the third stage of the study, numerical calculations and interpretation of the results were carried out

5.1.Description of the main components of the model

To build a hierarchical model, the main goal was identified – how to select an educational route.

The following alternatives were considered (types of educational routes):

- School-elective (T1).
- Supplementary education at school (T2).
- School-university (T3).
- School - Russian Academy of Sciences (T4).
- Network education (T5).

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Since the process of educational route selection is influenced by the students' individual characteristics as well as teachers' willingness to work with non-traditional technologies, the following criteria were chosen:

- Readiness of students (R).
- Students' motivation to succeed (M).
- Students' awareness about the opportunity to receive any additional education (A).
- Goal setting (or internal activity plan) (G).

These criteria, in their turn, are associated with the external factors that determine tutors support of school students learning according their educational routes and the way of the whole pedagogical process organization. To such acting forces (actors) were referred:

- Psychological and pedagogical support (PPS).
- Social and pedagogical support (SPS).
- Organizational and pedagogical support (OPS).

Psychological and pedagogical support is a special form of teachers' activity aimed at interaction to help the student in the process of his learning and professional development (Pryazhnikov, Vilkova, Loseva, Lobacheva, & Kholopova, 2018; Chistyakov & Rodichev, 2004). It is carried out by school teachers and educational organizations of supplementary education, teachers-psychologists.

The purpose of social and pedagogical support is adequate students' socialization and their individual development. During this process, the problems of school students and their causes are identified, the appropriate means of their solving are chosen. This way of support is implemented by teachers in supplementary education, employees of continuing education centers of universities, organizations dealing with various issues of professional orientation, management system aiming creating conditions (legal, scientific and methodological, informational, personnel, material and technical, monitoring) for the effective implementation of the tasks of psychological and pedagogical support of professional self-determination of students in educational organizations of different levels and types, as well as in specialized career guidance organizations and institutions (Blinov & Sergeev, 2015).

Organizational and pedagogical support. We identify this type of support, sharing the position of Usmanov (2015), who considers that "the use of the term" organizational-pedagogical "in relation to a certain range of problems indicates the insolubility of these problems by pedagogical or psychological-pedagogical means within the educational process" (p.119).

Organizational and pedagogical support is provided by departments of education, universities, Academy of Sciences, various educational funds, interdepartmental commissions, councils, school administration.

5.2. Research stages

Since the building model has four levels of hierarchy, it is necessary to determine the influence of each criterion and the force acting on the alternative selection. The study was conducted in three stages:

- Detecting the impact of criteria on the route selection.
- Revealing the influence of the actors on the selected criteria.
- Obtaining a composite vector of the influence of the criteria and actors on the route selection.

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Numerical calculations were carried out using the Saaty method AHP (Saaty, 2005):

- A matrix of pairwise comparisons of criteria for the goal was constructed (based on the data obtained at the first stage of the study).
- Priority vector, maximum eigenvalue, consistency index, consistency ratio were calculated.
- Matrices of pairwise comparisons of alternatives for each characteristic were constructed.
- For each active force, the priority vector, maximum eigenvalue, consistency index, consistency ratio were calculated.
- Total estimates for each alternative were calculated.
- The total consistency index (TCI), the total consistency ratio (TCR) was calculated. By value of the last parameter it is possible to judge reliability of result.

According to the estimates for the selected alternatives, it becomes possible to recommend an educational route, based on personal characteristics and control factors for each student.

6. Findings

Taking into account the selected alternatives and characteristics, a hierarchical model consisting of four levels was constructed (Figure 01).

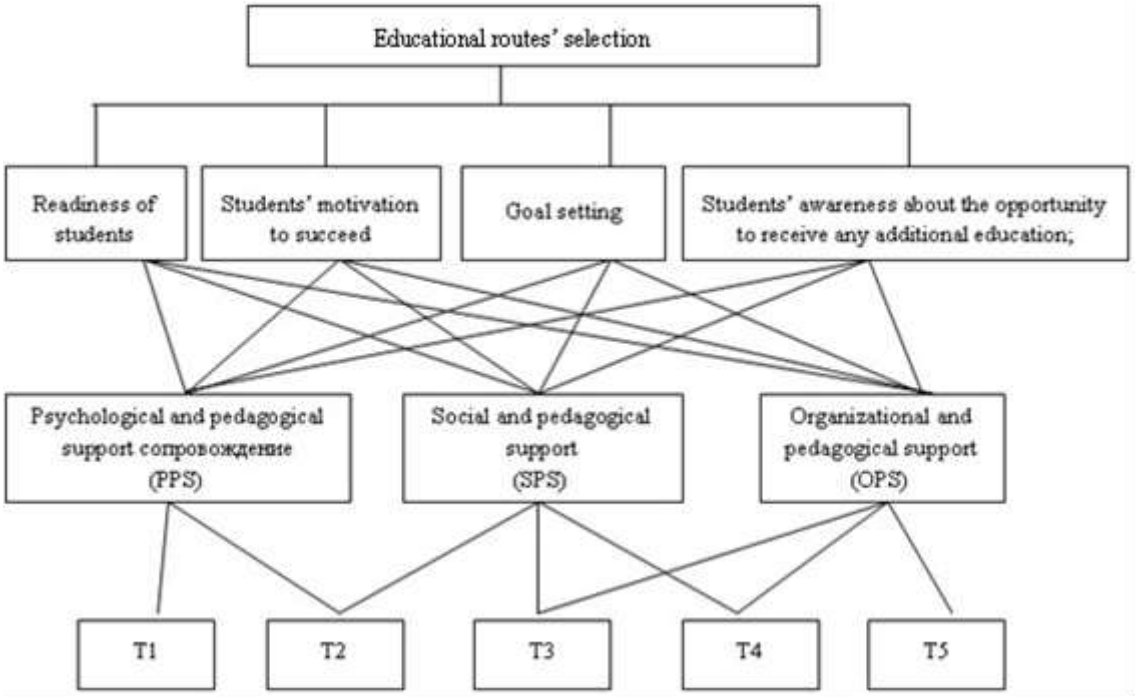

Figure 01. Hierarchical model of selecting an individual educational route

The Figure 01 shows that at each level of the hierarchy, the elements are independent quantities, and at the same time affect each other and the elements of another level. During the study the analysis of the selected educational routes effectiveness and their relation with presented characteristics was carried out. The characteristics are individual.

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In order to show the dependence of the selection among pedagogical alternatives (educational routes), numerical calculations were carried out for different variants of the characteristics values.

6.1.Route selection criteria study

Table 01 presents a matrix of pairwise comparisons of characteristics with each other. The priority scale is determined by experts according to the following rule (Saaty, 2005):

- if the first and second characteristics are equally important - put in the table 1;
- if the first is slightly more important than the second - put 3;
- if the first is much more important - put 5;
- if the first is clearly more important - put 7;
- if the first absolutely surpasses the second - put 9.

In compromise cases, the values 2,4,6,8 are selected.

Table 01. Comparison of criteria regarding the educational routes` selection

	R	**M**	**A**	**G**
R	1	0.2	0.2	0.333
M	5	1	3	1
A	5	3	1	0.125
G	3	1	8	1

As seen from the table, such characteristics as motivation for success, awareness, according to experts, are more significant than, for example, the willingness of students to learn in non-traditional forms.

According to this table, the priority vector was calculated in the following way: divide the elements of each column by the sum of the elements in this column (normalize the elements of the columns), find the sum of the elements of the columns of the resulting matrix and divide the obtained values by the number of elementsю

As a result, the following vector of characteristics priorities was obtained (0,037; 0,123; 0,12: 0,16; 0,56). To determine the results' consistency, calculate the largest eigenvalue λ_{max} by the rule: multiply the original matrix on the right by the priority vector, divide the elements of the resulting vector into the corresponding elements of the priority vector, find the average value of the obtained elements. In the case of matrix consistency, the eigenvalue value is equal to the number of elements in the matrix n. next, CI (consistency index) and CR (consistency ratio) were calculated (Saaty, 2005).

CR value less than or equal to 0.10 is considered acceptable.

The calculations showed that for the initial matrix of pairwise comparisons (Table 01) the corresponding values are λ_{max}=7,1; IC=0.53; CR=0.47.

6.2. Study of the actors` influence on the criteria

The next step of the analysis was to compare the actors for each characteristic. The corresponding tables of pairwise comparisons for each characteristic were compiled (Table 02).

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Table 02. Comparison educational routes with respect to five characteristics

R	**PPS**	**SPS**	**OPS**		**M**	**PPS**	**SPS**	**OPS**
PPS	1	0,333	0,2		PPS	1	0,333	0,2
SPS	3	1	0,333		SPS	3	1	0,2
OPS	5	3	1		OPS	5	5	1
G	**PPS**	**SPS**	**OPS**		**A**	**PPS**	**SPS**	**OPS**
PPS	1	0,333	0,2		PPS	1	0,333	0,333
SPS	3	1	0,2		SPS	3	1	0,333
OPS	5	5	1		OPS	3	3	1

For each characteristic, priority vectors, maximum eigenvalue, consistency index, consistency ratio are calculated:

- Readiness of students (R) - the priority vector (0,069; 0,21; 0,41), λmax= 4,3; CI=0,038; CR=0,043.
- Students' motivation to succeed (M) - the priority vector (0,052; 0,093; 0,59), λmax= 4,2; CI=0,071; CR=0,079.
- Students' awareness about the opportunity to receive any additional education (A).- the priority vector (0,22; 0,27; 0,51), λmax= 4,2; CI=0,071; CR=0,079.
- Goal setting (or internal activity plan) (G) - the priority vector (0,39; 0,15; 0,46), λmax=4,3; CI=0;1; CR=0,12.

As can be seen from the results, the consistency ratio for each of the five matrices of pairwise comparisons for the selected characteristics is less than 0.10, which indicates the reliability of the result.

6.3.Final vector of influence of criteria and actors to educational routes` selection

To obtain the final vector of influence, actors` comparisons for each characteristic were carried out. Tables of pairwise comparisons for each characteristic are presented in table 03, 04, 05.

Table 03. Table of pairwise comparisons for PPS with respect to educational routes` selection

PPS	**T1**	**T2**	**T3**	**T4**	**T5**
T1	1	8	5	3	3
T2	0,125	1	8	3	3
T3	0,2	0,2	1	8	3
T4	0,333	0,333	0,125	1	3
T5	0,333	0,133	0,133	0,133	1

λmax=4,5; CI=0;33; CR=0,57

Table 04. Table of pairwise comparisons for SPS with respect to educational routes` selection

SPS	**T1**	**T2**	**T3**	**T4**	**T5**
T1	1	8	8	2	2
T2	0,125	1	4	8	4
T3	0,125	0,25	1	6	5
T4	0,5	0,125	0,167	1	0,125
T5	0,5	0,25	0,2	8	1

λmax=4,7; CI=0;06; CR=0,10.

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Table 05. Table of pairwise comparisons for OPS with respect to educational routes` selection

OPS	**T1**	**T2**	**T3**	**T4**	**T5**
T1	1	0,5	0,167	0,125	0,125
T2	2	1	0,333	1	0,133
T3	6	3	1	0,2	0,2
T4	8	1	5	1	5
T5	8	3	5	0,2	1

λmax=4,6; CI=0;07; OS=0,10.

On the basis of the obtained data it is possible to obtain a General ranking of each type of educational route. As a result of the calculations the eigenvector of the first matrix was obtained A (table 01): A(0,037; 0,123; 0,12: 0,16; 0,56). For the second group of matrices (table. 02) the matrix B eigenvectors is obtained.

Table 06. Matrix B

	R	M	A	G
PPS	0,165	0,625	0,713	0,601
SPS	0,604	0,119	0,072	0,097
OPS	0,231	0,256	0,191	0,302

Matrix C eigenvectors for the third group of matrices (table. 03, 04, 05) is presented in table 07.

Table 07. Matrix C

	PPS	SPS	OPS
T1	0,119	0,127	0,064
T2	0,064	0,281	0,213
T3	0,213	0,120	0,112
T4	0,150	0,221	0,307
T5	0,454	0,242	0,304

As a result, we get the final vector of priorities of the CBA (0,15; 0,137; 0,204; 0,36, 0,123). Calculating the total consistency index (TCI) and the total consistency score (TCR) we get TCI; TCR =0.031. Since the consistency ratio is less than 0.10, the result is valid.

Thus, the most preferable for the above expert values is the educational route School-Russian Academy of Sciences (T4). This is due to the fact that in this case, the most important, according to experts, were chosen awareness and motivation for success, and as an influence – organizational and pedagogical support.

With the aim of studying the influence of different criteria on the educational route selection, similar calculations were carried out for other expert evaluations.

7. Conclusion

As shown above, in the case where such characteristics as motivation for success and awareness, according to experts, are more important than, for example, readiness for using non-traditional teaching methods, and at the same time such an indicator as OPS is the greatest, such types of educational routes as T4 (network training) or T3 (School-Academy of Sciences) are preferred. Thus, if there is correct

information for students and organizational resources, recommendations on routes selection can be given, depending on the preferences of students.

During the study, calculations were made for other expert evaluations. Thus, if experts consider more important characteristic of the PPS, while the other tables of pairwise comparisons remain unchanged, the vector of priorities of the types of education routes becomes equal (0,325; 0,259; 0,179; 0,157; 0,08), OIS=0.024; OOS=0.021. Thus, the rating of the first (T1) and second (T2) types of educational trajectory increases and T3 and T4 decreases.

The results can be explained by the fact that in this case, a great role is played by the work of school teachers and teachers-psychologists, who can independently provide training for students on individual educational routes, which involve optional classes at school, reading elective courses or the organization of supplementary education at school.

At change of expert estimates for the characteristic of R (readiness) and SPS (social and pedagogical support), the vector of priorities for types of the route becomes equal (0,079; 0,326; 0,232; 0,10; 0.26); OIS=0.048; OOS=0.043. That is, in this case, the most fruitful educational results can be given by such education route as T2 (supplementary education at school) and T3 (School-University).

In case the G (goal setting) index increases and experts consider the ATP to be the most important, we have obtained the following priority vector for the types of education routes becomes equal (0,169; 0,211; 0,202; 0,07; 0.348); OIS=0.048; OOS=0.043. That is, in this case, the most fruitful educational results are given by the T5 route (network learning).

Numerical modeling of the process of education route selection with help of AHP method (Saaty, 1980) showed that the choice of educational alternatives to achieve optimal educational results requires taking into account internal and external factors, establishing their relationship, justifying the preferred route based on the evaluation of the alternatives, identifying the influence of external factors on the process of education route selection. Thus, the tasks of the study were solved.

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