Formation of Individual Educational Trajectories in Preparing IT specialists

Authors:

• Larisa K. Ptitsyna¹, Nidal El Sabayar Shevchenko²
  Dept. of Information Management Systems
  The Bonch-Bruevich Saint-Petersburg State University of Telecommunications
  Saint Petersburg, Russia
  ptitsina_lk@inbox.ru¹, nzs.vus@gmail.com²

• Mikhail P. Belov
  Dept. of Information Management Systems
  The Bonch-Bruevich Saint-Petersburg State University of Telecommunications
  Saint Petersburg, Russia
  milesa58@mail.ru

• Aleksey V. Ptitsyn
  Dept. of Safety Information Technologies
  National Research University “ITMO” Saint Petersburg, Russia
  pticin@inbox.ru
I. INTRODUCTION

In the information society, engineering education for preparing personnel in the field of IT technologies is one of the basic directions in the development of the digital economy.

The goal-setting of higher education programs for preparing IT specialists is focused on creating key conditions for the formation of personnel for the digital economy, developing a competencies system, improving scientific and educational environments and their content, taking into account the labor market in the context of the requirements of the digital economy.
The proposed concept, unlike the known ones, is based on “soft” integration and end-to-end linking of its system-forming components in an active ecosystem.

A key role in soft integration is given to the open basis of intelligent information hyper technologies, combining the vast variety of different paradigms of intellectualization.
II. The concept of individual educational technologies formation

The indicators of the implementation of the proposed concept are:

• the average number of students on a unique educational trajectory;
• the proportion of students with a unique individual educational trajectory;
• the average score of the results of intermediate certification of students in the disciplines of individual educational trajectories;
• the average number of approbations of students on individual educational trajectories;
• the average number of publication of the students on individual educational trajectories;
• the average number of applications for contests of students on individual educational trajectories;
• the average number of victories in competitions of students on individual educational trajectories;
• the proportion of students who use individualized navigation services for educational space.
III. INTEGRATED FORMALIZATION SYSTEMS

1) Definition of statistical profiles:

– the integrated information protection system is characterized by \( f_N(k_N) \), \( k_N = 1, 2, ..., M_1 \) probability density distribution of \( k_N \) discrete information protection time.
– The active monitoring agent is described by \( f_{am}(k_{am}) \), \( k_{am} = 1, 2, ..., M_2 \) probability density distribution of \( k_{am} \) discrete monitoring time.

The specified characteristics satisfy the following condition:

\[
\sum_{k_N=1}^{M_1} f_N(k_N) = 1, \quad \sum_{k_{am}=1}^{M_2} f_{am}(k_{am}) = 1
\]
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2) The formalization provides for the transition from a statistical profile of the functioning of the means of an intelligent integrated information protection system to the $P_N$ matrix description:

$$P_N = \begin{bmatrix} 0 & f_N(M_1) & f_N(M_1-1) & f_N(M_1-2) & f_N(M_1-3) & \cdots & f_N(1) \\ 0 & 0 & 1 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}$$

Matrix $P_N$ is characterized by dimension $(M_1+1) \times (M_1+1)$.

The statistical profile of the functioning of the active monitoring agent is presented by $P_{am}$ matrix description:

$$P_{am} = \begin{bmatrix} 0 & f_{am}(M_2) & f_{am}(M_2-1) & f_{am}(M_2-2) & f_{am}(M_2-3) & \cdots & f_{am}(1) \\ 0 & 0 & 1 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}$$

Matrix $P_{am}$ is characterized by dimension $(M_2+1) \times (M_2+1)$. 
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3) The generalized P matrix description of the processes of the joint functioning of the means of an intelligent complex information protection system and a monitoring agent according to the ring method of their integration is determined as follows:

\[
P = \begin{bmatrix}
0 & f_N(M_1) & f_N(M_1-1) & f_N(M_1-2) & f_N(M_1-3) & \ldots & f_N(1) & 0 & 0 & 0 & \ldots & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & \ldots & 0 & 0 & 0 & 0 & \ldots & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & \ldots & 0 & 0 & 0 & 0 & \ldots & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & \ldots & 0 & 0 & 0 & 0 & \ldots & 0 & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
0 & 0 & 0 & 0 & 0 & \ldots & 0 & p & 0 & 0 & \ldots & 0 & (1-p) \\
0 & 0 & 0 & 0 & 0 & \ldots & 0 & 0 & f_{am}(M_2) & f_{am}(M_2-1) & \ldots & f_{am}(2) & f_{am}(1) \\
0 & 0 & 0 & 0 & 0 & \ldots & 0 & 0 & 0 & 0 & \ldots & 0 & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
1 & 0 & 0 & 0 & 0 & \ldots & 0 & 0 & 0 & 0 & \ldots & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \ldots & 0 & 0 & 0 & 0 & \ldots & 0 & 1
\end{bmatrix}
\]

The presented square matrix has dimension \((M_1 + M_2 + 2) \times (M_1 + M_2 + 2)\)
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4) The $f_{N,am}(k_{N,am})$ probability distribution density of the $k_{N,am}$ discrete time of information protection during active monitoring is found according to the relation:

$$f_{N,am}(k_{N,am}) = P_{1,(M_1+M_2+2)}^{(k_{n,am})} - P_{1,(M_1+M_2+2)}^{(k_{n,am}-1)}$$

where $P_{1,(M_1+M_2+2)}^{(k_{n,am})}$ is the $(1,(M_1 + M_2 + 2))$-th element of the $k_{n,am}$-th power of the matrix $P$;

$P_{1,(M_1+M_2+2)}^{(k_{n,am}-1)}$ is the $(1,(M_1 + M_2 + 2))$-th element of the $(k_{n,am} - 1)$-th power of the matrix $P$;

$(k_{n,am} - 1)$ is the power of the matrix $P$;

$K_{N,am}$ is the upper bound of discrete time;

The value of $K_{N,am}$ is defined as the smallest integer satisfying the condition:

$$1 - \sum_{k_{N,am} = 1}^{K_{n,am}} (P_{1,(M_1+M_2+4)}^{(k_{n,am})} - P_{1,(M_1+M_2+4)}^{(k_{n,am}-1)}) \leq \delta$$

where $\delta$ — is an arbitrarily small quantity.
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Finding the statistical characteristics of the discrete time of information protection during the joint operation of the means of an intelligent integrated system and a monitoring agent according to the ring method of their integration is carried out through linear algebra operations from the theory of Markov chains:

\[ T = (I - PQ)^{-1}, \quad t = Te, \]
\[ D = T(2T_0 - I) - T^*; \quad d = (2T - I)t - t^*, \]

where
- \( I - (M_1 + M_2 + 1) \times (M_1 + M_2 + 1) \) is a unit matrix;
- \( PQ - (M_1 + M_2 + 1) \times (M_1 + M_2 + 1) \) is the matrix obtained from matrix \( P \) by deleting its last row and last column;
- \( T - (M_1 + M_2 + 1) \times (M_1 + M_2 + 1) \) is the matrix formed by elements \( T_{i,j} \), \( i, j = 1, 2, \ldots, (M_1 + M_2 + 1) \); \( T_{i,j} \) is the mathematical expectation of the number of stays of the Markov chain in the \( j \)-th state, if the \( i \)-th state is taken as the initial one;
- \( e - (M_1 + M_2 + 1) \times 1 \) is a single column-vector;
- \( t - (M_1 + M_2 + 1) \times 1 \) is a column-vector consisting of \( t_i \) elements; \( t_i \) is the average time spent on performing information protection in the \( i \)-th initial state;
- \( T_0 - (M_1 + M_2 + 1) \times (M_1 + M_2 + 1) \) is the matrix obtained from square matrix \( T \) by replacing with zeros all the elements not lying on the main diagonal;
- \( T^* \) is the matrix obtained from the matrix \( T \) by squaring each of its elements;
- \( D - (M_1 + M_2 + 1) \times (M_1 + M_2 + 1) \) is the matrix formed by elements \( D_{i,j} \), \( i, j = 1, 2, \ldots, (M_1 + M_2 + 1) \); \( D_{i,j} \) is the variance of the number of times the Markov chain stays in the \( j \)-th state, if the \( i \)-th state is taken as the initial one;
- \( t^* \) is the column-vector obtained from vector \( t \) by squaring each of its elements; \( d - (M_1 + M_2 + 1) \times 1 \) is the column-vector, consisting of elements \( d_i \); \( d_i \) is the variance of the discrete time of information protection in the \( i \)-th initial state.
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The approximate estimation of $E(k_{N,am})$ mathematical expectation and $D(k_{N,am})$ variance of the discrete time $k_{N,am}$ of information protection is carried out using the probability distribution density $f_{N,am}(k_{N,am})$ with active monitoring:

$$E(k_{N,am}) \approx \sum_{k_{N,am}=1}^{K_{N,am}} k_{N,am} f_{N,am}(k_{N,am})$$

$$D(k_{N,am}) \approx \sum_{k_{N,am}=1}^{K_{N,am}} (k_{N,am} - E(k_{N,am}))^2 f_{N,am}(k_{N,am})$$

The degree of approximation to the exact values may increase as the set value of $\delta$ decreases.

The derived analytical definitions for estimating $t_1$, $d_1$, $E(k_{N,am})$, $D(k_{N,am})$ are introduced into the subsystem of algebraic invariants of an integrated information protection system with the aim of quickly detecting possible manifestations of destructive influences. The following relations are defined as algebraic invariants:

$$t_1 - E(k_{N,am}) < \varepsilon_1,$$

$$d_1 - D(k_{N,am}) < \varepsilon_2,$$

where $\varepsilon_1$ and $\varepsilon_2$ are given arbitrarily small quantities.
CONCLUSION

THE PROPOSED “SOFT” CONCEPT OF FORMATION OF INDIVIDUAL EDUCATIONAL TRAJECTORIES AND ITS CORRESPONDING INTEGRATED FORMALIZATION SYSTEMS ARE EXTENSIONS FOR SITUATIONAL QUALITY MANAGEMENT OF ENGINEERING EDUCATION.
Thanks for your attention!

Speaker’s contacts:

Nidal El Sabayar Shevchenko

*The Bonch-Bruyevich Saint-Petersburg State University of Telecommunications*

e-mail: nzs.vus@gmail.com