CONCEPTUAL APPROACHES TO THE INTERACTION OF LABOR MARKET ENTITIES AND EDUCATIONAL INSTITUTIONS IN THE RUSSIAN FEDERATION WITHIN THE ECOSYSTEM BASED ON NEURAL NETWORK MECHANISMS

ABORDAGENS CONCEITUAIS PARA A INTERAÇÃO DE ENTIDADES DO MERCADO DE TRABALHO E INSTITUIÇÕES EDUCACIONAIS NA FEDERAÇÃO RUSSA DENTRO DO ECOSSISTEMA COM BASE EM MECANISMOS DE REDE NEURAL

ENFOQUES CONCEPTUALES DE LA INTERACCIÓN DE LAS ENTIDADES DEL MERCADO LABORAL Y LAS INSTITUCIONES EDUCATIVAS EN LA FEDERACIÓN DE RUSIA DENTRO DEL ECOSISTEMA BASADOS EN MECANISMOS DE REDES NEURONALES

Elena Eduardovna ALENINA[1]
Vera Vitalievna ZIULINA[2]
Ilya Aleksandrovich ALENIN[3]
Sergey Vladimirovich BOLOTNIKOV[4]
Dmitry Vladimirovich REDIN[5]
Lyubov Viktorovna BORODACHEVA[6]

ABSTRACT: The purpose of the study: to develop and describe, the process of functioning of a neural network system of expert justification of management decisions in the field of preparation of educational programs for promising activities using graphical modeling methods. Results: conceptual approaches to ensuring the interaction of labor market entities and educational organizations of the Russian Federation within the information and communication ecosystem based on neural network mechanisms described in the BPMN 2.0 notation have been proposed. The main subjects of the system have been characterized through the "pool" and "swimline" tools, their interaction through the "flow", "messages flows" tools, the main operations displayed through private processes data mining, IDSS, communication driven and document driven interaction. The scientific novelty of the study: the concept of strategic interaction between the subjects of the labor market and educational institutions of the Russian Federation based on automation of communication and the use of neural network mechanisms has been proposed.

[1] Moscow Polytechnic University, Moscow – Russia. Assistant Professor. ORCID: https://orcid.org/0000-0002-0109-3064. E-mail: e-alenina@mail.ru
[2] Moscow Polytechnic University, Moscow – Russia. Assistant Professor. ORCID: https://orcid.org/0000-0002-9419-1121. E-mail: ziulinavv@yandex.ru
[3] Moscow Polytechnic University, Moscow – Russia. Lecturer. ORCID: https://orcid.org/0000-0002-7373-2419. E-mail: e-alenina@mail.ru
[4] Moscow Polytechnic University, Moscow – Russia. Assistant Professor. ORCID: https://orcid.org/0000-0002-3419-2800. E-mail: boatman_in@mail.ru
[5] Moscow Polytechnic University, Moscow – Russia. Professor. ORCID: https://orcid.org/0000-0003-4165-6885. E-mail: dmired@mail.ru
[6] Moscow Polytechnic University, Moscow – Russia. Senior Lecturer. ORCID: https://orcid.org/0000-0001-7778-2854. E-mail: lyubov.borodacheva@mail.ru

KEYWORDS: Neural network systems. Description. Modeling. BPMN 2.0. Data mining. Communication driven. Document driven interaction. Management solutions. Educational institutions.

***RESUMO**: O objetivo do estudo: desenvolver e descrever, o processo de funcionamento de um sistema de rede neural de justificação pericial de decisões de gestão no domínio da preparação de programas educacionais para atividades promissoras utilizando métodos de modelagem gráfica. Resultados: foram propostas abordagens conceituais para garantir a interação de entidades do mercado de trabalho e organizações educacionais da Federação Russa dentro do ecossistema de informação e comunicação com base em mecanismos de rede neural descritos na notação BPMN 2.0. Os principais temas do sistema foram caracterizados através das ferramentas "pool" e "swimline", a sua interação através das ferramentas "flow", "fluxos de mensagens", as principais operações apresentadas através de processos privados de mineração de dados, IDSS, comunicação dirigida e interação documental dirigida. A novidade científica do estudo: foi proposto o conceito de interação estratégica entre os sujeitos do mercado de trabalho e as instituições de ensino da Federação Russa com base na automação da comunicação e no uso de mecanismos de rede neural.*

***PALAVRAS-CHAVE**: Sistemas de redes neurais. Descrição. Modelagem. BPMN 2.0. Mineração de dados. Comunicação dirigida. Interação orientada a documentos. Soluções de gerenciamento. Instituições educacionais.*

***RESUMEN**: El propósito del estudio: desarrollar y describir, el proceso de funcionamiento de un sistema de red neuronal de justificación experta de decisiones de gestión en el campo de la preparación de programas educativos para actividades prometedoras utilizando métodos de modelado gráfico. Resultados: se han propuesto enfoques conceptuales para asegurar la interacción de las entidades del mercado laboral y las organizaciones educativas de la Federación de Rusia dentro del ecosistema de información y comunicación basados en los mecanismos de redes neuronales descritos en la notación BPMN 2.0. Los principales sujetos del sistema se han caracterizado a través de las herramientas "pool" y "swimline", su interacción a través de las herramientas "flow", "message flow", las principales operaciones desplegadas a través de procesos privados data mining, IDSS, comunicación impulsada y interacción documental impulsada. La novedad científica del estudio: se ha propuesto el concepto de interacción estratégica entre los sujetos del mercado laboral y las instituciones educativas de la Federación de Rusia basado en la automatización de la comunicación y el uso de mecanismos de redes neuronales.*

***PALABRAS CLAVE**: Sistemas de redes neuronales. Descripción. Modelado. BPMN 2.0. Minería de datos. Comunicación impulsada. Interacción impulsada por documentos. Soluciones de gestión. Instituciones educativas.*

Introduction

Development processes in modern socio-economic systems require the use of new management tools based on the use of information technologies. One of the trends is the emergence of ecosystems of heterogeneous entities organized according to the network principle. The functioning of such conglomerates is caused by several problems:

1) The implementation of large projects requires the organization of effectively working conglomerates of participants – different in scale, the scope of activity, internal structure.

2) Changes in the labor market – obsolescence and the introduction of new professions, the emergence of new requirements of employers.

3) The delay in the reaction to these changes in educational institutions – which creates a gap between the emerging needs of the labor market and its satisfaction in the form of training carriers of the required competencies.

4) Indirect and non-linear nature of the relationship between the subjects of the labor market and educational institutions, the lack of uniform markers in the formation of educational programs.

5) The absence of an ecosystem that unites the subjects of the labor market and suppliers of personnel for them (educational institutions).

The issues of subject-object integration were considered in the article by V.L. Senderov, S. V. Bolotnikov, and V. A. Vasin (2017) "Neural network interaction of expert councils in the interests of making strategic decisions". We propose the concept of using neural network technologies for a comprehensive assessment of the labor market and the formation of a single ecosystem combining functional analytical elements and elements responsible for the decision (expert councils based on dissertation councils of universities). However, there is no description in this paper of the interaction mechanism between elements in the system.

The problem of human-machine interaction is considered in the article by V. A. Vasin and S. V. Bolotnikov (2019) "Specialist as an element of the artificial intelligence system". The categorization of the main elements has been given, a description technique has been proposed, but there is no graphical model of the functioning of the proposed neural network system.

The development of separate postulates of the concept of coordination of educational institutions and subjects of the labor market is carried out in the article of V. V. Mazur and V. L. Senderov (2019) "The mechanism of neural network change management in the process of vocal education", however, no attempt has been made to describe the proposed system using well-known methods.

The rationale for the use of modern tools for managing the process of coordination of heterogeneous economic entities in socio-economic systems is proposed in the article of Alenina *et al*. (2021) "Management tools in modern distributed social communities".

The use of a neural network system with a Temporal Fusion Transformer architecture to coordinate the strategic planning process is proposed in the article of V. Moskalenko, and N. Fonta, (2021) "The Method of Constructing a Development Trajectory as the Basis of an Intelligent Module for Strategic Planning of the EPM System". The considered system forms the strategic position of the organization based on market factors but does not consider human-machine interaction as a key mechanism of the system.

Therewith, forecasting the demand of labor market subjects using a SOM-type neural network is considered in the article of J. F. Zheng and R. J. Ma (2021) "Analysis of Enterprise Human Resources Demand Forecast Model Based on SOM Neural Network", however, in this example, the neural network system is used locally for data mining, does not include a decision support system (IDSS).

The main approaches to the use of neural networks for management tasks are described in the article of Y. C. Wu and J. W. Feng (2018) "Development and Application of Artificial Neural Network", in particular, the data mining, communication driven, document driven technologies considered in this article for the coordination of economic entities have been proposed.

The use of machine learning algorithms and neural networks of the Deep Q-Network type for differentiation of environmental factors and strategic planning of project actions has been proposed in the article by Gao *et al*. (2020) "Application of Deep Q-Network in Portfolio Management", however, practical application is considered on a narrow example of stock market management.

Aspects of assessing the professional competencies of employees using neural network technologies that are important for this work have been considered in the article by A. K. Petrova (2021) "Application of Neural Networks in the HR Tasks", but the focus of the research is more focused on the internal environment of the organization.

The system of rating assessment of individual subjects used in this study is proposed in the article by X. T. Li and Y. Sun (2021) “Application of RBF neural network optimal segmentation algorithm in credit rating” on the example of differentiation of credit rating of clients-legal entities in B2B.

The hypothesis of this study: the application of the graphical modeling method based on the use of BPMN 2.0 notation will sufficiently characterize the mechanism of interaction of

elements within the proposed neural network system of expert justification of strategic management decisions for the formation of new educational programs in the Russian Federation.

Materials and Methods

The purpose of this work is to form a graphical model (scheme, structure) reflecting the functioning of the proposed neural network system for substantiating strategic management decisions for the formation of new educational programs using BPMN 2.0 business process description notations.

Tasks:

1) Describe the main elements of the proposed neural network model.

2) To construct a graphical model of the main modules of the proposed system based on the BPMN 2.0 business process notation.

3) Within the framework of the model: to integrate expert and dissertation councils of educational institutions as subjects determining decision-making of the proposed neural network system.

4) Based on a graphical method to describe the ecosystem in the labor market of the Russian Federation, uniting potential employers and institutions of higher education of the Russian Federation based on a communication system.

The following methods were used in the work: description and graphical modeling of business processes, including Flow Chart Diagram, Data Flow Diagram, Role Activity Diagram, BPMN 2.0 notation, graphical method, text description of processes.

Results

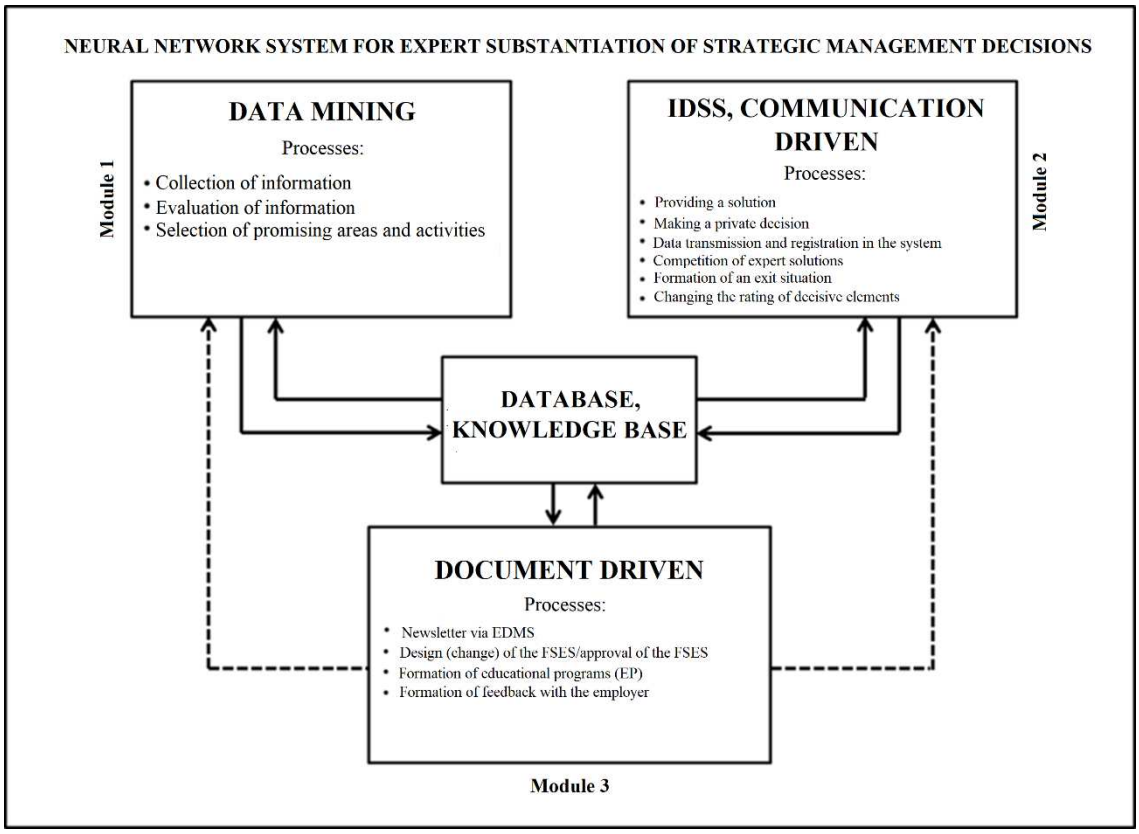
Three functional modules can be distinguished in the proposed neural network system of expert justification of strategic management decisions (Figure 1).

The functionality of module 1 is a study of the labor market based on quantitative accounting of information sources (by the method of content analysis) using the neural network algorithm of information retrieval data mining.

The functionality of module 2 is the adoption of a principled decision of the expert and dissertation councils of the Russian Federation on information and methodological support for a specific type of activity, recognizing it as promising.

The functionality of module 3 is the creation of methodological support for a new type of activity in the form of specific educational programs. The neural network algorithm can be used here to organize feedback from employers of the labor market of the Russian Federation.

Figure 1 – The main modules of the neural network system of expert justification of strategic management decisions in the formation of new educational programs



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The complete processes of each of the modules can be subdivided into local subprocesses, also described in the BPMN 2.0 notation.

Module 1 (Data mining).

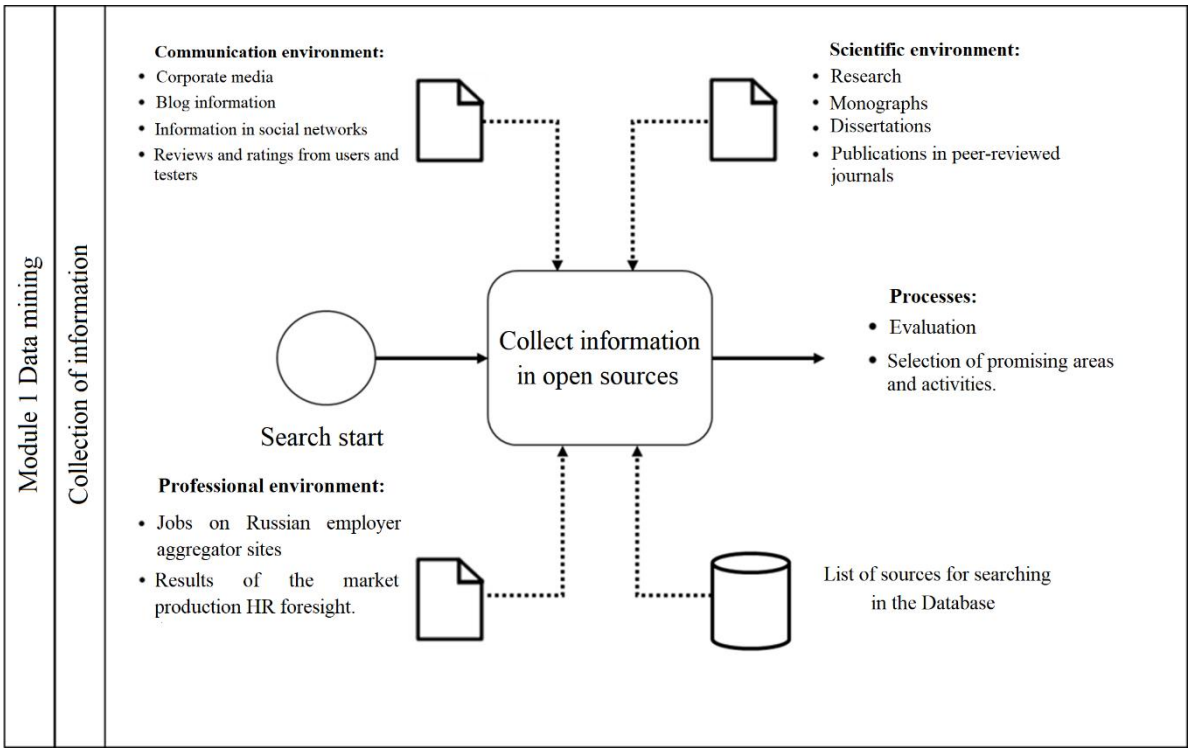
"The process of labor market research by a neural network system, collection, structuring of information about promising (innovative) activities". Includes subprocesses:

1) *Collecting information* (Figure 2). The neural network algorithm starts searching for information about promising types of activities using a list of information sources included in the Database, the Knowledge Base of the system, a calendar plan for searching by category (BOLOTNIKOV; VASIN; SENDEROV, 2017):

- sources from the scientific community – contain the results of research and assessments of the scientific community;

- open information sources – data from communication channels (mass media, social networks, blogs);
- feedback from employers – expressed in vacancies on specialized information resources;

Figure 2 – Description of the business process: module 1 Data-mining, information collection



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2) *Assessment* (Figure 3). It includes an assessment of the information collected and structured in the Database using the content analysis method (quantitative frequency method) based on neurons of the "adaline" type. The input signal of the network can be units of a text array – phrases.

3) *Selection of promising areas and types of activities.* Each signal acquires a numerical value (weight) depending on the frequency of occurrence in the array of the analyzed text. The units with the highest weight are passed by the neurons of the network to be entered into the Database, transferred to the evaluation by the decisive elements of the network. For selection, the system sets a threshold for passing, depending on the size of the data array. Signals that have passed the screening procedure are issued in the form of an application for expert evaluation (BOLOTNIKOV; VASIN; SENDEROV, 2017; BOLOTNIKOV; VASIN, 2019).

Module 2. (IDSS, Communication Driven).

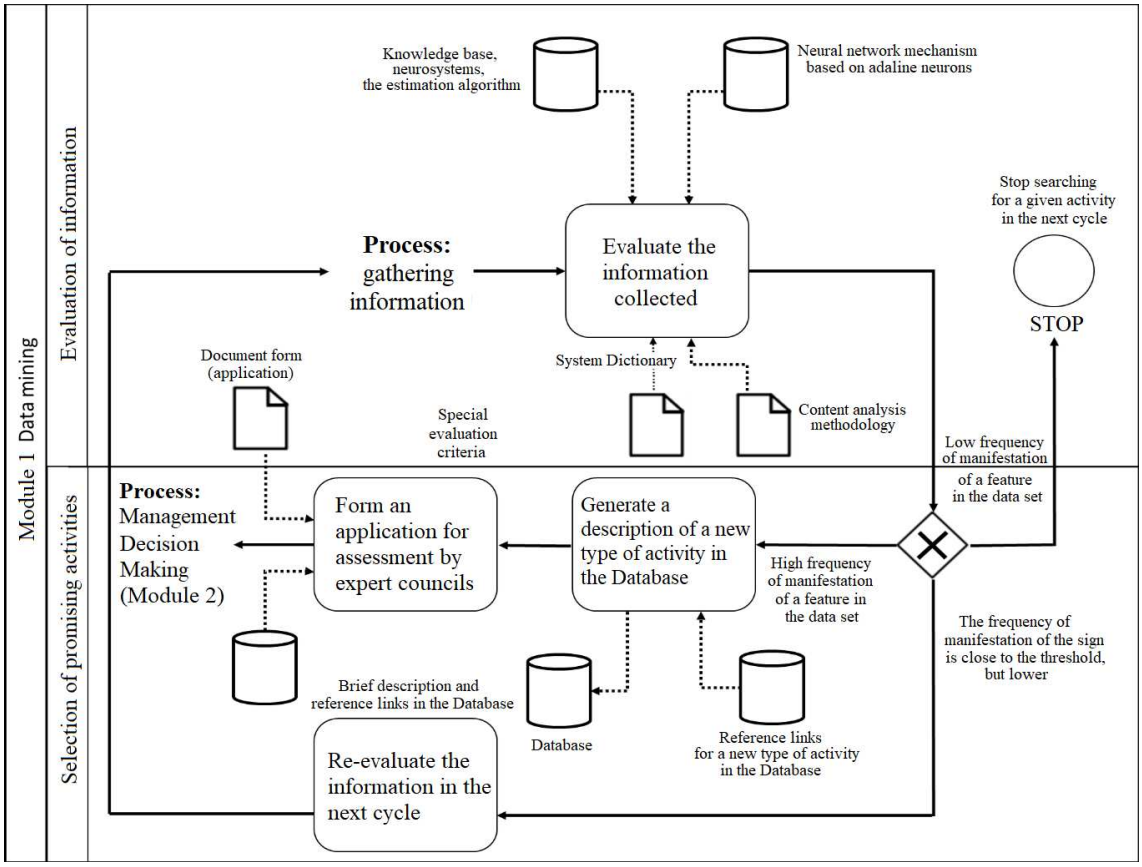
"The process of making a strategic decision on the formation of an educational program for a specific type of activity".

Includes subprocesses (Figure 4):

1) *Providing a solution.* Applications for new types of activities (keywords, brief description, links to sources) that have passed the competition in the neural network are brought to the expert (dissertation) councils registered in the system as decisive elements. The status of a particular council is determined by its previous activities (BOLOTNIKOV; VASIN; SENDEROV, 2017).

2) *Making a private decision.* The decisive elements of the network (expert councils) evaluate specific applications according to the selected point-rating scale. The assessment is made remotely through the information resources of the neurosystem. The output result of this phase is a signal in the form of an assessment of a specific council for individual applications (BOLOTNIKOV; VASIN, 2019; MAZUR; SENDEROV, 2019).

Figure 3 – Description of the business process: Module 1 Data-mining, evaluation of information, selection of promising activities



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3) *Transfer and registration of data in the system*. The evaluation results are uploaded to the system by expert councils based on personal registration data: individual number, weight (based on the rating in terms of the previous decisions of the council that have passed the selection). The score for each application is encoded by numerical values: the number of points scored; the rating of the evaluating council. The rating of the expert council can be changed based on the result of subsequent processing of their signals (MAZUR; SENDEROV, 2019).

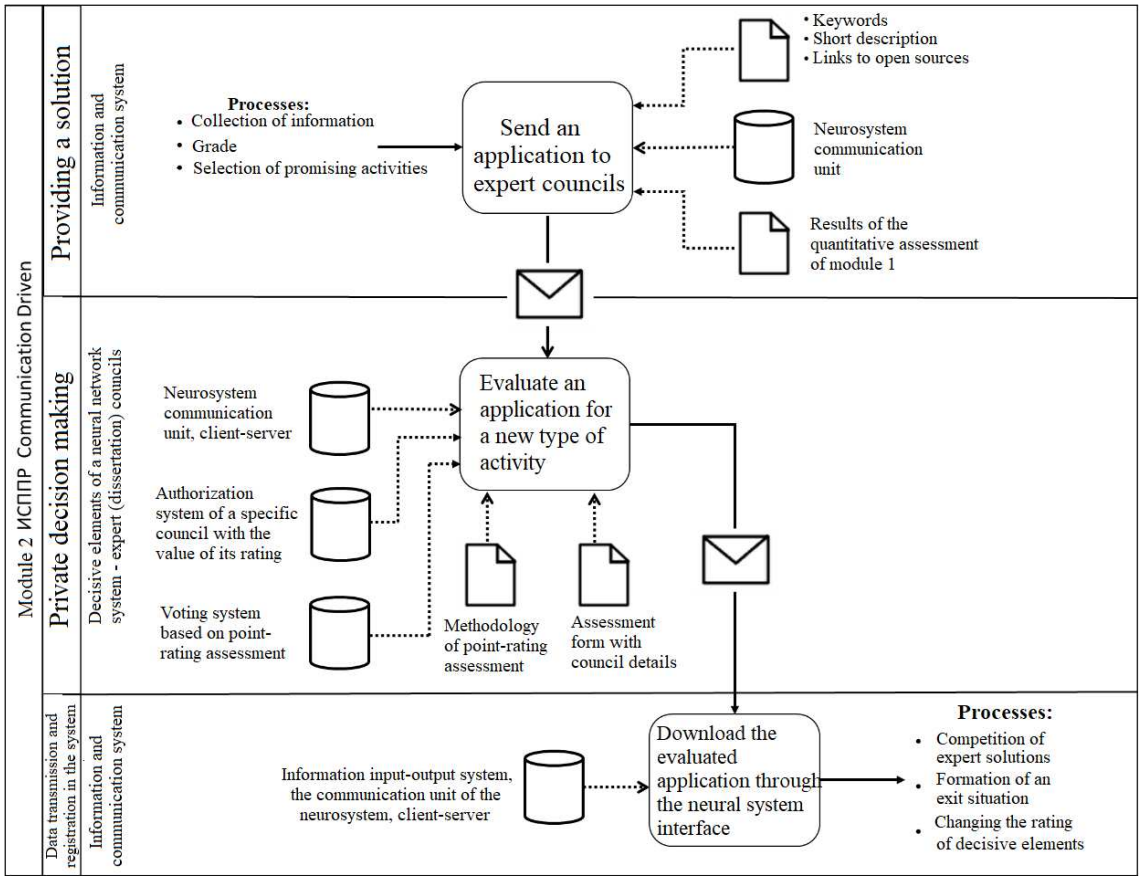
4) *Competition of expert solutions* (Figure 5). A neural network algorithm based on the Rules of the Knowledge Base, the threshold of activation of neurons set in it, implements a mechanism for competing input signals from crucial elements for each specific application.

Each signal received by a separate neuron of the network competes with others based on two parameters: the numerical value of xi and the weight value of a separate wi council (BOLOTNIKOV; VASIN; SENDEROV, 2017).

5) *Formation of the output situation*. The adder of a single neuron of the system considers (BOLOTNIKOV; VASIN; SENDEROV, 2017):

- total number of signals;
- the number of signals with a value above the activation threshold;
- the number of signals from highly rated councils.

Figure 4 – Description of the business process: module 2 of the IDSS, Communication Driven – decision support, private decision making, data transmission, and registration in the system



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Based on internal competition, the output situation in the neuron is formed in terms of a signal with a high numerical value of ratings highly rated councils. It is issued in the form of an application for the design of an educational program, including name, a brief description of the type of activity, brief justification, average rating from expert councils. Applications with ratings below the input threshold are eliminated, with average values are entered into the database for a new data mining cycle.

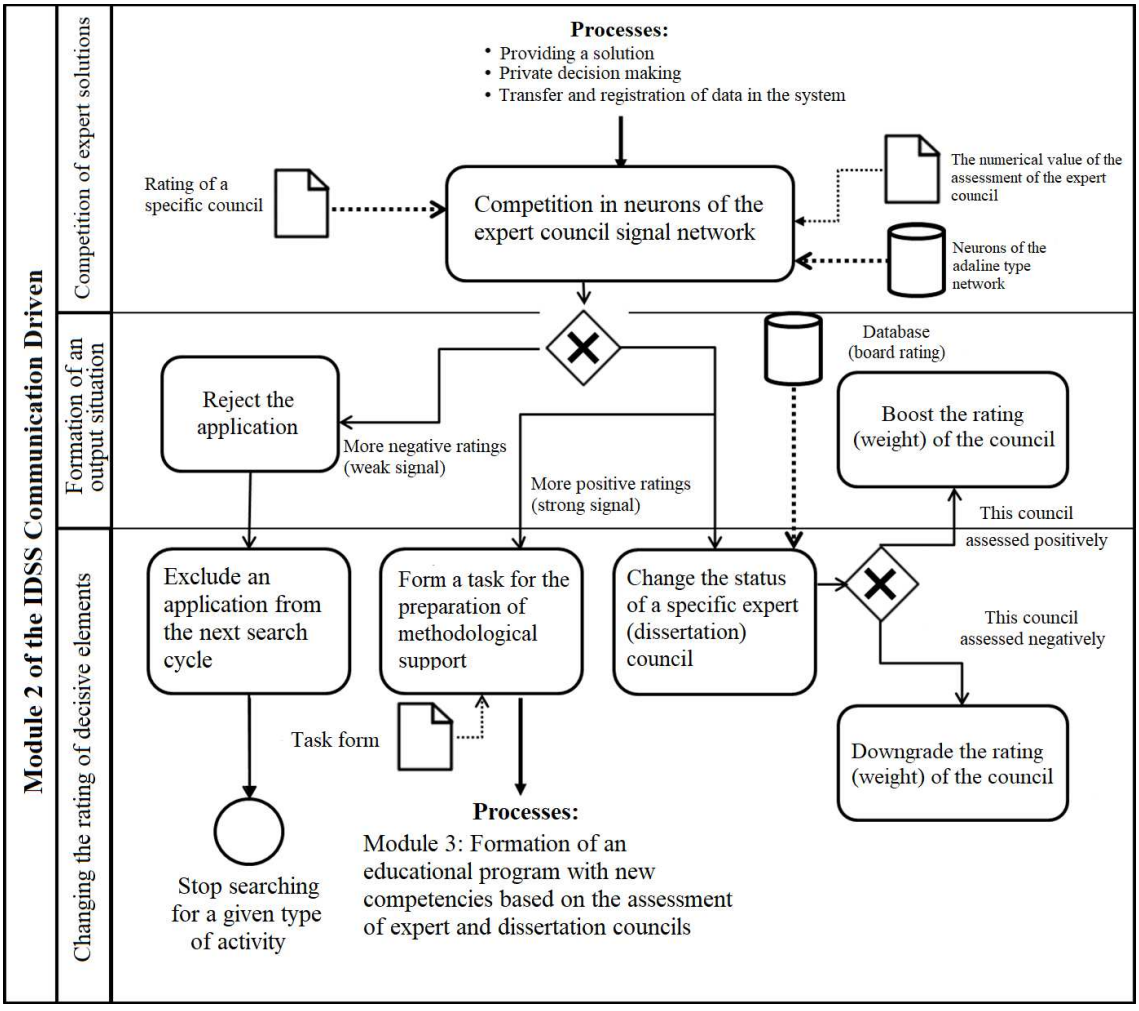
6) *Changing the rating of crucial elements (expert and dissertation councils)*. For councils that have positively evaluated applications accepted for further development, the individual rating is increased with fixation in the Database. Councils the ratings of which differed significantly from the average value within each cycle are downgraded in the rating. Councils with a rating below the threshold level are excluded from the system. Specialization formation: highly rated councils are linked (specialized) to specific thematic sections (areas of activity) within which they were given high marks (BOLOTNIKOV; VASIN, 2019).

Module 3 (Document driven).

"Formation of an educational program with new competencies based on the assessment of expert councils". Includes subprocesses (Figure 6):

Newsletter via EDMS. An application for the creation of a basic educational program for a new type of activity is brought through the electronic document management system to the subjects who carry out the design of the program – Educational and Methodological associations (UMO) of universities. The application includes the following details: sphere activity, possible name of the OP; brief description; point-rating assessment with the rating of expert councils, links to information sources where the maximum numerical manifestation of the feature is recorded during the data mining cycle (BOLOTNIKOV; VASIN, 2019).

Figure 5 – Description of the business process: module 2 of the IDSS Communication Driven – competition of expert solutions, formation of an output situation, change in the rating of decisive elements



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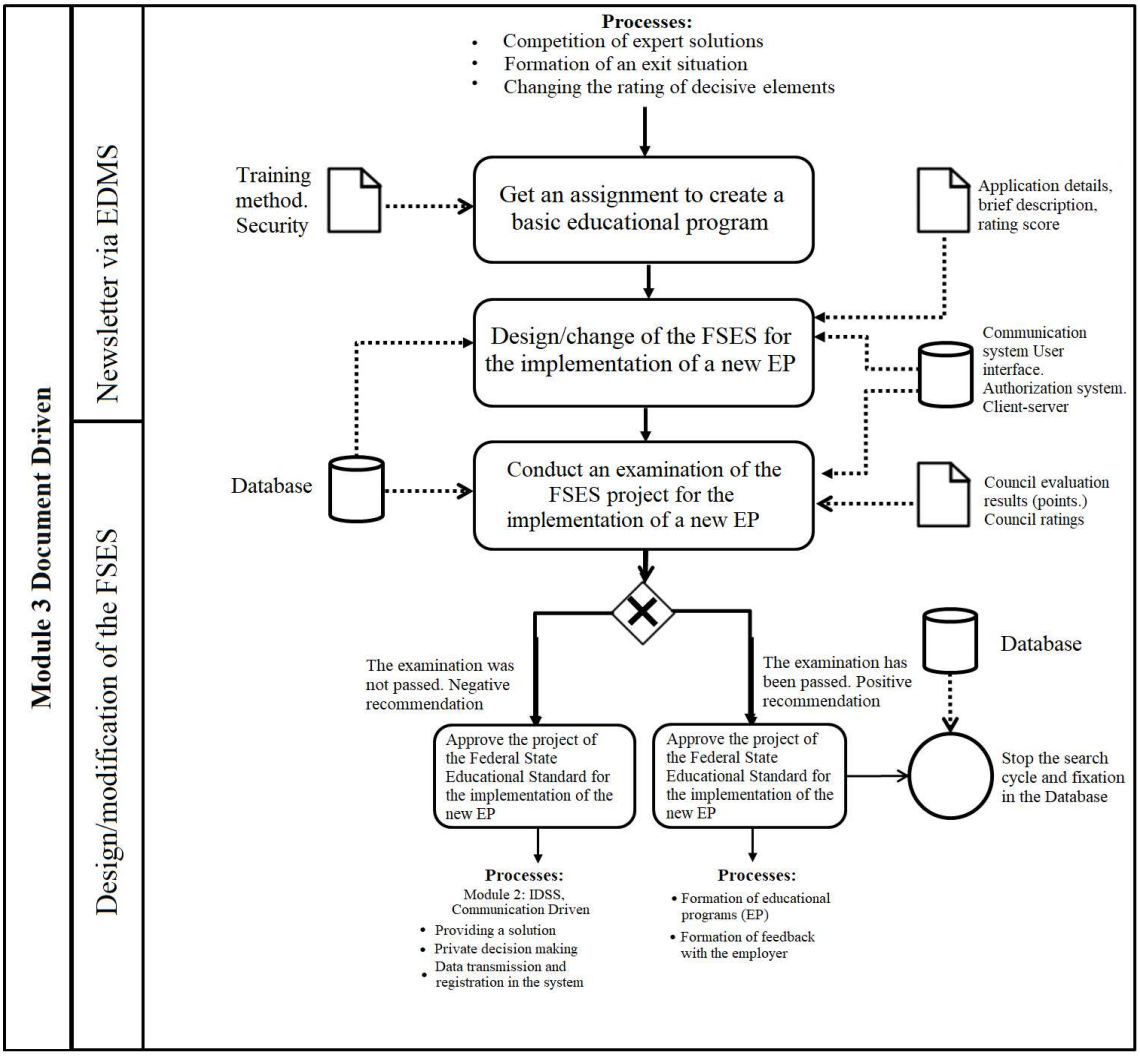
1) *Design (modification) of the FSES/approval of the FSES.* Based on the application, Educational and methodological associations of universities form a draft amendment (supplement) of the standard describing a new type of activity.

The draft (additions) is brought to the Ministry of Science and Higher Education of the Russian Federation. Educational and methodological associations apply to the project information on a new type of activity obtained from the Neural network Database. The Ministry of Science of the Russian Federation accepts or rejects the proposed changes. Operations, depending on the results of the decision: if the project is rejected, the application is sent to module 2 of the system for reconsideration by the expert council; when approved, this type of activity is excluded from subsequent data mining cycles of module 1 (BOLOTNIKOV; VASIN, 2019).

Figure 6 – Description of the business process: module 3 Document Driven – newsletter through the EDMS, the design of the FSES



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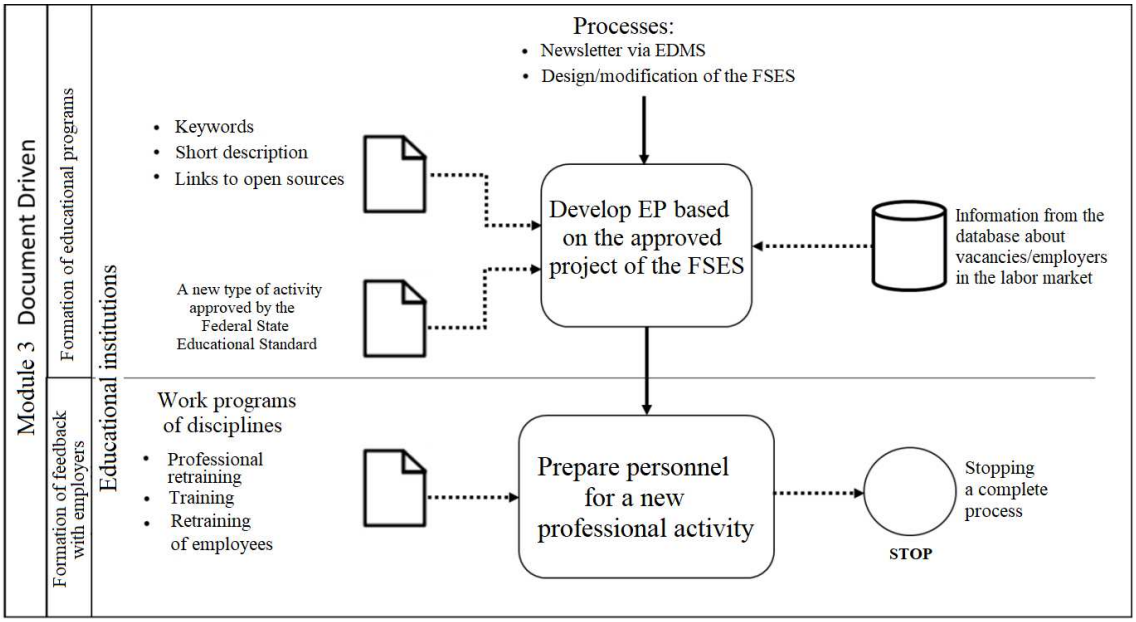
2) *Formation of educational programs (EP)* (figure 7). Based on the positive assessment of the Ministry of Science of the Russian Federation, educational institutions form the main educational programs (EP) of higher education. EP design support is formed based on Database information through the individual authorization of educational institutions as participants in the system (MAZUR; SENDEROV, 2019).

3) *Formation of feedback with employers.* Educational institutions, within the framework of the specialization of the developed EP, can use information about a new type of activity in the neural network system Database for communication with employers, formation of contacts with target audiences of programs, career guidance, professional development, and formation of additional vocational training (BOLOTNIKOV; VASIN; SENDEROV, 2017; BOLOTNIKOV; VASIN, 2019; MAZUR; SENDEROV, 2019).

Figure 7 – Description of the business process: module 3 of the IDSS "Document Driven" – the formation of educational programs, the formation of feedback with employers



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Discussion

1. In the framework of this study, the BPMN 2.0 business process description notation was used, based on which a simple graphical model (diagram) of the proposed neural network system (Figure 1) was formed.

2. The main elements of the neural network system are displayed in the form of three interacting modules (Figure 1), each of the modules is decomposed into separate elements (Figures 2-7).

3. The characteristics of the main subjects of the proposed neural network system are given ("pool", "swimline" tools, Figures 2-7) and a schematic diagram of their interaction within the system is formed ("flow", "messages flows" tools, Figures 2-7).

4. The main operations of private business processes data mining, IDSS, communication driven, document driven have been described in graphical form based on BPMN 2.0 ("actions", "events" tools, Figures 2-7), in text form.

5. Based on the BPMN 2.0 notation, the scheme of integration of expert councils into a neural network system by forming a local business process in the communication driven module (Figure 2) is reflected.

6. Conceptually, an ecosystem is defined that unites potential employers and educational institutions of the Russian Federation based on a communication system, by forming an end-to-end multiprocess with feedback (Figure 1).

Conclusion

The following effect can be distinguished from the introduction of a neural network system for substantiating strategic management decisions for the formation of new educational programs in the Russian Federation:

1) The cyclical accumulation of information about new types of activities in the neural network system will allow forming an array of data characterizing the development of the labor market of the Russian Federation.

2) The array can be used by economic entities for business analysis, strategic analysis, workforce planning, market, technological foresight, business modeling, indicative planning.

3) The cyclical nature of the functioning of the neural network system will allow forming the communication between educational institutions and employers in the form of a circular model with a rapid response to changes and an increase in the number of information links.

4) Reduction of the duration of the period between the appearance of the need for employers in a promising type of activity and the reaction of educational institutions.

5) Reducing the duration of the strategic decision-making process based on the results of business analysis by economic entities.

6) Increasing information support for promising activities (startups, innovations, innovations) due to globalization and the formation of a unified information ecosystem.

7) Improving the efficiency of forming horizontal management structures and coordinating the activities of project teams through internal communications of the neural network system.

8) The ability to assess the quality of the activities of specific expert councils through a rating mechanism based on their decisions.

The practical significance of this study lies in the use of the developed schemes of local business processes to provide data mining in the study of professional needs of the labor market and the organization of decision-making support in the field of evaluation of promising activities.

Authors' Contributions

Elena Eduardovna Alenina: Goal setting and formation of research tasks, analysis of problems, formulation of hypotheses, motivation, coordination of participants.

Vera Vitalievna Ziulina: Working with information sources, description of the neural network mechanism of module 1, collection and structuring of research materials.

Ilya Aleksandrovich Alenin: Working with English-language information sources, description of the neural network mechanism of modules 1 and 2.

Sergey Vladimirovich Bolotnikov: Structuring of the material, design, preparation of illustrations, drawings. Formation of schemes in the BPMN 2.0 business process description notation.

Dmitry Vladimirovich Redin: Control of research methodology, critical evaluation of research results.

Lyubov Viktorovna Borodacheva: Working with English-language information sources, description of the neural network mechanism of modules 2 and 3.

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