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Project portfolio modeling for the regional dual education development

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ABSTRACT

The aim of the article is to present a method of project portfolio management for the regional development of dual education under conditions of uncertainty using expert methods. In the project portfolio management standard, portfolio formation is represented by a group of alignment processes, but their practical application in a specific subject area remains at the discretion of the developer. For the design and development of software systems, visual process models are developed for a specific subject area. The article presents the development of a complex system of dual education through the formation of a portfolio of projects. The data obtained allowed to determine that the portfolio management methodology can be successfully implemented in Ukrainian dual education. To improve the processes of portfolio management, a practical implementation of the processes of portfolio formation in the IDEF0 notation was carried out. A simplified algorithm for forming a project portfolio has been developed, which allows increasing the speed of response to changes in portfolio management in educational sphere. The proposed solution of the educational system development through portfolio using expert methods that are distinguished by the application of the Pareto rule for building a scenario for the system development. On the basis of the developed methodology for forming a portfolio of innovative projects, the process of optimizing the efficiency of the portfolio of innovative projects with determining their individual priorities is studied on the example. The application of the developed procedures for planning the portfolio management of the dual education system in the central region of Ukraine is demonstrated. The results obtained have made it possible to make sure that the system development management in conditions of incomplete information covers the areas of process management, and helps to minimize the impact of uncertainty on the efficiency of the portfolio of projects implementation.

Keywords: Project portfolio formation; project positioning matrix; regional dual education; process approach; expert method

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INTRODUCTION

From the perspective of Ukraine's integration into the European economic space, the project management methodology, which is harmonized in line with international practice, is a national asset. However, such an important organizational resource as project portfolio management remains underutilized for the restructuring of many sectors of the economy. In an uncertain global environment, the requirements for project management are becoming more stringent. Ukraine needs mechanisms to quickly adapt to the changes that accompany the processes of the globalization of any society.

For a long time, it was believed that projects could only play a secondary and auxiliary role in change management. Over time, it has become clear that the rationale for implementing the project achievement of strategic goals for the development of a complex system.

The relevance of the article is due to the fact a methodological framework for project portfolio management will be solved by applying expert approach rises to a higher level, which is the level of strategic management of the entire enterprise system. At this level, project management is already considered here as a method of ensuring the methods in project management. The research should use the theory of active systems development, system analysis.

The relevance of the article is due to the fact that management systems often fail to keep pace with the changes taking place in society. An indicator of this situation is the insufficient application of the methodology of programs and project portfolio management at the tactical level of the development of complex systems. At the same time, the losses of society as a result of unsuccessful programs based on inadequate decision-making procedures are many times higher than the funds required training personnel with the appropriate qualifications.

However, initial data when selecting projects for the dual education development portfolio are characterized by inaccuracy and incompleteness.

Therefore, to understand the concept of implementing the development of dual education systems based on the portfolio, visual modeling using expert evaluations is proposed.

The article aims to analyze and summarize the methods of forming a portfolio of projects for the development of dual education in the region**.**

Research methods. The methodological basis of the research is the basis of the system-process approach to project management. The scientific and technical problem is solved by means of mathematical modeling in accordance with standard processes for project portfolio management.

1. ANALYSIS OF LITERARY DATA

It is logical to start an analysis of modern concepts of projects, programs and project portfolios management with the documents generally accepted in the global project environment. These are undoubtedly the standards of portfolio [3] and programme management [4] developed by the Project Management Institute.

According to [2], the main differences of portfolio management are as follows:

– a portfolio is a continuous business process;

– the portfolio has a broad strategic focus;

– the portfolio audience is concentrated at the level of top managers;

– the main focus is on component grouping and decision-making.

Portfolio management focuses on the strategy of “doing the right thing”. The relationship of portfolios, programs and projects in the standard [3] is presented through hierarchy and subordination. A Portfolio is a set of projects or programs and other activities brought together for the purpose of effective management of these activities to achieve the strategic goals of an organization or other entities [5, 6], [7]. Projects and programs in a portfolio are not necessarily interdependent or directly related.

All components of the project portfolio have certain common features that reflect:

– the organization’s made or planned investment;

– related to the strategic goals and objectives of the organization;

– some distinctive features that allow the organization to group them for more effective project management;

– project portfolio components are measurable, i.e. they can be measured, classified and prioritized.

Project portfolio management involves activities aimed at achieving the strategic goals of the organization by forming, optimizing, monitoring and controlling, managing changes in the project portfolio under certain constraints. Project portfolio management provides a link between the level of strategic management in the organization and the level of project and programmed management [8, 9], [10].

The use of the dynamic management model in the formation of a project portfolio provides support in making decisions on the feasibility of including a project that is not provided with resources from the customer [11]. PMO provides a link between 31 projects, programs, portfolios, organizational evaluation systems and its development strategy, such as the Balanced Scorecard (BSC) [12, 13]. Strategic management in project-oriented organizations is used on the basis of modern IT technologies and is enhanced by specialized software tools [14, 15], [16, 17].

2. PROCESS APPROACHE IN MANAGING EDUCATIONAL PROJECTS

Currently, the management of complex systems development through the implementation of a project portfolio is actively developing. A portfolio is a set of projects, programs, supporting portfolios and operational activities that are managed as a group to achieve strategic goals. Today, as Ukraine undergoes important reforms of its state structure, much attention is being paid to the introduction of management process modeling. This applies to both the national and regional levels. The official vector of the state towards integration with the European economic area requires the implementation of the best practices of foreign reforms, where a wealth of experience has been accumulated in generalizing and systematizing the process approach. Integration into the European community involves the application of generally accepted international norms, rules and instruments, which is pointed out by many researchers [1, 2]. Projects are included in the organization's portfolio to directly or indirectly influence the achievement of strategic goals, or due to the expected high financial and time characteristics of their implementation in the short term. Projects can contribute to the achievement of the organization's strategic goals if they are aligned with its strategy. This presupposes the existence of a strategy itself, which is formalized in the form of a strategic plan in accordance with the theory of strategic management. In this regard, the PMBoK methodology assigns the

main role to the project management office, which combines data and information obtained from projects and assesses the degree to which higher-level strategic objectives are met.

Portfolio management involves ensuring that projects and programs are reviewed to set priorities for resource allocation and that the portfolio is in line with the system's development strategy. The strategic goals of the system and its project portfolio are inextricably linked and influence each other. The identification of strategic initiatives and the results obtained through the implementation of these initiatives contribute to the implementation of the strategy and allow assessing its effectiveness in the long term.

The relationship between the strategy and the project portfolio can be illustrated in the form of a repeating cycle consisting of four stages:

1. Transformation of strategy into projects.
2. Project portfolio planning.
3. Portfolio management.
4. Re-evaluation of the strategy and portfolio.

In the PMI knowledge system [3], project portfolio management is represented by two groups of processes:

Aligning Processes Group – includes elements of portfolio management that assign portfolio components to certain categories and evaluate them for inclusion/exclusion in the portfolio;

Monitoring and Controlling Processes Group – based on performance indicators, which are used to periodically align the portfolio components with the strategic objectives.

The Aligning Process Group provides up-to-date information on the programmed/project activities aimed at achieving strategic goals, allowing for the evaluation and management of the portfolio components.

This group of processes is activated when the strategic goals of the organization are updated as part of the formation of annual/quarterly budgets and plans for the near future or in the event of changes in the business environment. (Fig. 1) [3].

The sequence and content of project portfolio management can be traced by the following most informative inputs/outputs of the processes in Table 1 [3].

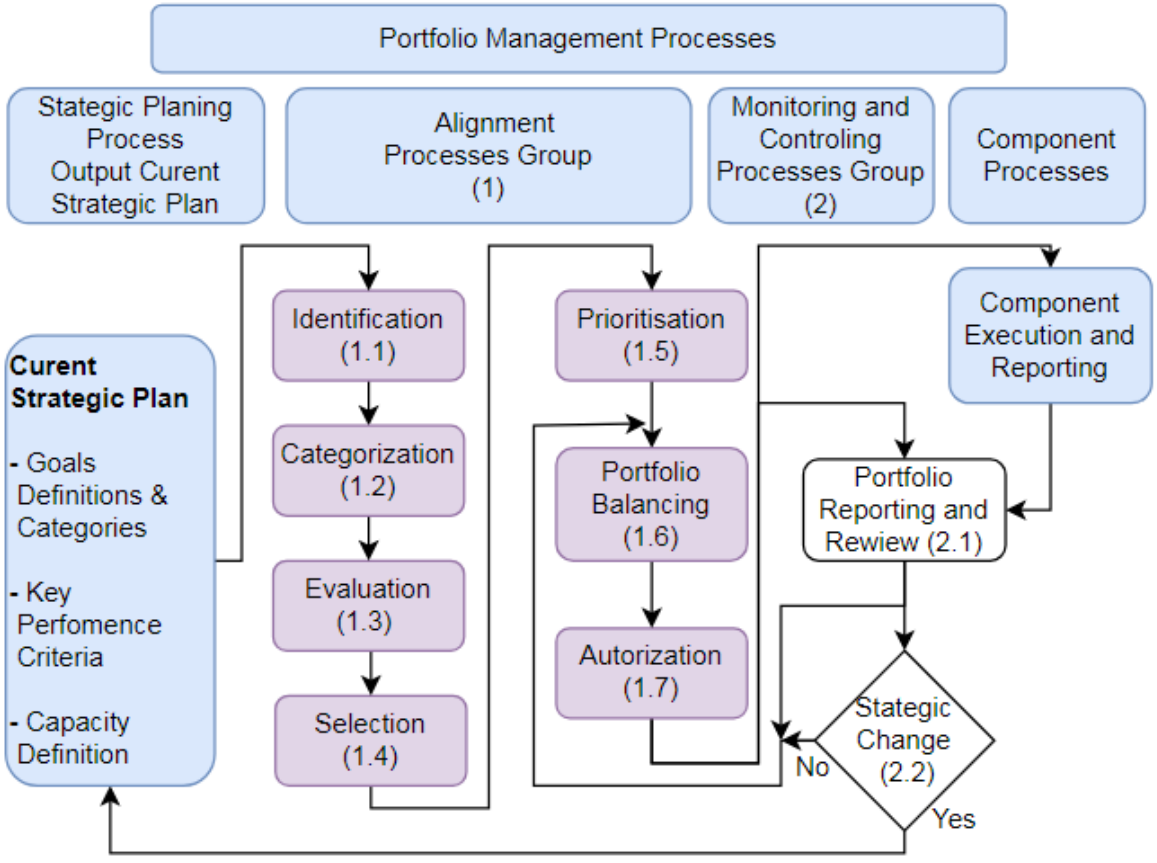

Fig. 1. **Portfolio management processes**

Source: **compiled by the [3]**

Table 1. **The processes of project portfolio formation**

Portfolio management process	Input	Output
Identification	Strategic plan, a list of candidate components, Component Outline Profile (OPA)	List of components, main descriptions of each component, list of rejected components
Categorisation	List of components, main component category descriptions	List of categorised components
Evaluation	Strategic plan, list of categorized components, basic component descriptions	List of categorized and assessed components, the value of each component, visual representations, recommendations on the assessment results
Selection	Strategic plan, list of categorized and assessed components, cost estimates for each component, visual representations of the assessment results	List of categorized, assessed and selected components, recommendations
Prioritisation	List of categorized, assessed and selected components	List of categorized components according to the strategic category
Portfolio balancing	List of categorized components in accordance with the strategic category, portfolio management criteria, portfolio management progress metrics, limitations and assumptions, and recommendations for portfolio re-grouping based on a review of the statements	List of approved portfolio components, the final updated list of main alternatives, the distribution of updated/improved portfolio components

Source: **compiled by the [3]**

2.1. Constructing a process model "Formation of a portfolio of regional dual education development projects"

Today, the computer technology market offers many special programs, methodologies and tools for modelling business processes. There are already standardized time-tested ones. Their key advantage is simplicity and accessibility. Many modern methodologies are based on SADT (Structured Analysis and Design Technique), the IDEF family of standards (Icam DEFinition, where Icam stands for Integrated Computer-Aided Manufacturing), and algorithmic languages. Among the many case-based tools, AllFusion Process Modeler (previously known as BPwin and ERwin) is the best in terms of price/quality ratio, so we will perform the modelling in this tool environment [18].

a) Constructing a context diagram of the process model

The formation of a portfolio of projects for the development of dual education includes the processes necessary for the examination of project applications, for the formation or updating of a portfolio of projects in accordance with the concepts of system dynamics. These processes ensure the work of the expert group in selecting projects for the portfolio, taking into account the changing external environment and stakeholder expectations. A contextual diagram of the process model is shown in Fig. 2 below.

Inputs: *Candidate project components* proposed by internal or external stakeholders for inclusion in the project portfolio.

OPA (Organisational Process Assets) are plans, processes, policies, procedures and knowledge bases specific to and used by the implementing organization (according to PMBoK) [19]. These assets can also be experiences, practices, and knowledge that can be used to implement or manage a project [20], [21], [22] and are the inputs too many project management processes.

Tools and methods: *Stakeholders* – internal and external stakeholders in those projects and programs that either apply for inclusion in the portfolio or are part of it.

PMO – Project Management Office – a structural unit that implements strategic project management, standardizes project management processes, and facilitates the exchange of resources, methodologies, tools and methods. An expert group can be formed from stakeholders and the PMO team.

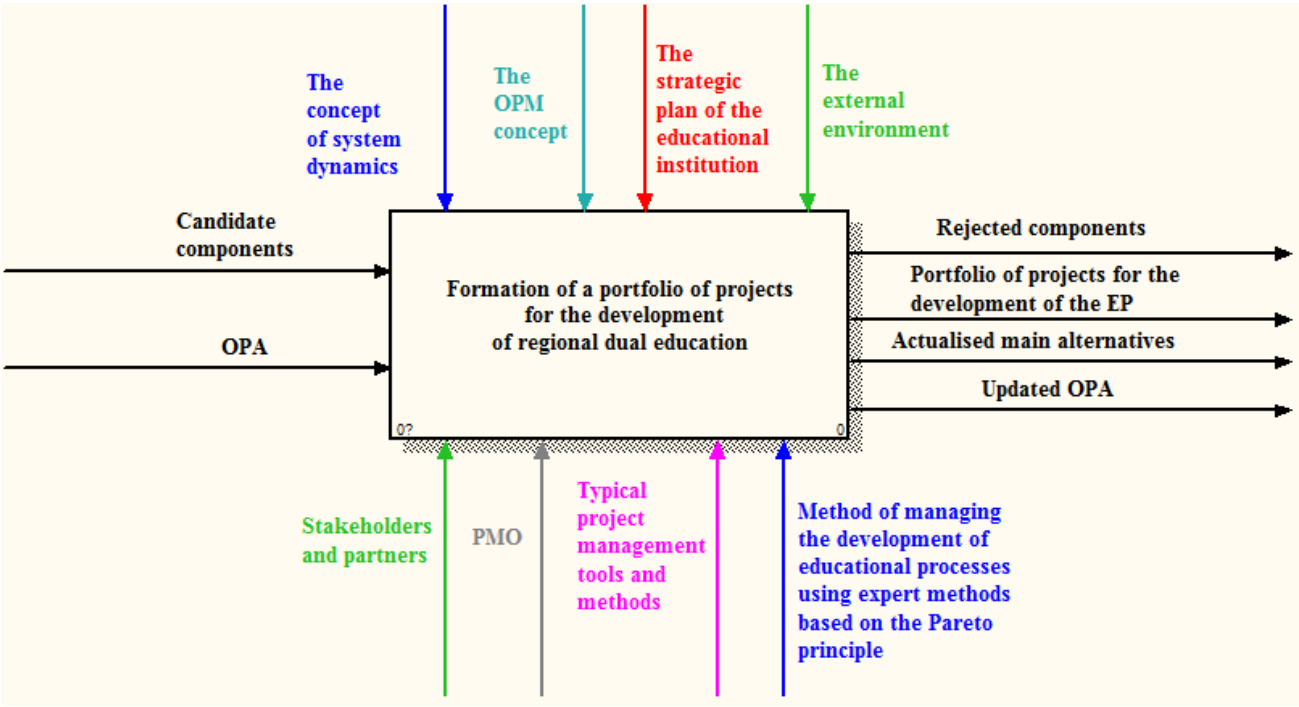

Fig. 2. **Context diagram of the process model "Formation of a portfolio of projects for the development of regional dual education"**
Source: **compiled by the authors**

Typical project management tools and methods are those tools and methods that are recommended by the PMBoK for use in managing certain processes.

We will describe the method of managing the development of educational processes under conditions of uncertainty using expert methods after the decomposition diagram.

Control and constraints:

The concept of system dynamics is an approach to managing a development portfolio as a complex system that studies its behavior over time and depending on the structure of the system elements and the interaction between them. It also includes: cause and effect relationships, feedback loops, reaction delays, environmental influences, etc.

The OPM concept is Organizational Project Management, which integrates portfolio, programs and project management with organizational delivery tools to achieve strategic goals.

External environment factors need to be considered when developing a strategy for adapting to changes in the external environment of project implementation.

The strategic plan of an organization is a long-term document (usually with a planning horizon of 3 to 5 years) that describes the main goal of the organization's activities and establishes the relationship between certain categories of goals and objectives to achieve them, as well as key indicators that will be used to measure performance (see Fig. 1 for signs). The sustainable development of an organization should be the result of.

Outputs: *Rejected components* are those proposals that may be rejected for the following reasons: if the submitted project does not comply with the organization's Strategy; if the project application is evaluated negatively; if the priority of the type of the applied project is zero in the "RME Recommendations on the priority threshold by project type".

Portfolio of regional dual education development projects is a portfolio of projects of an educational institution (list of approved portfolio components), balanced in accordance with the priority of sustainable development criteria defined in the Strategic Plan of the educational institution.

Updated main alternatives final updated list of main alternatives, distribution of updated/improved portfolio components.

Updated ORAs are updated plans, processes, policies, procedures, and knowledge bases related to the organization's process assets (ORAs). Updating them is not part of the project work. They are usually established or updated by a unit external to the project.

b) Constructing a diagram a0 of the top-level process decomposition

The top-level process decomposition is carried out in IDEF0 notation according to the SADT methodology [18], [23], [24]. The inputs and outputs, methods and tools of the process were migrated to the decomposition diagram (Fig. 3). According to Diagram A0 of the top-level decomposition, the processes of project portfolio formation include: identification, categorization, selection, prioritization, and portfolio balancing. The main inputs and outputs of the project portfolio formation processes are shown in Table 1.

*Recommendations based on the results of evaluation and selection*s are management feedback, as is appropriate for portfolio management processes.

2.2. A method of managing the development of educational processes using expert methods based on the pareto principle

The main informational difficulties associated with the processes of project portfolio formation and determining the use of expertise [25, 26]:

– statistical information is not reliable;

– some of the information is qualitative and cannot be quantified;

– the necessary information can be obtained, but it is not available at the time of decision-making;

– there is a large group of factors that may affect the implementation of the decision in the future, but they cannot be accurately predicted;

– there are potentially different schemes for implementing the decision, and the limitation of some resources leads to the choice of one option at the expense of others.

The following stages of the expertise can be summarized as follows [27]:

1) formulation of the purpose of the expertise;

2) formation of a group of analysts to implement organisational measures and process the results;

3) selection of experts for the main expertise;

4) conducting surveys;

5) processing and analysis of expert opinions;

6) synthesis of objective and subjective information to formulate a decision.

The result of an expert assessment is a conclusion based on competence in an applied aspect, area of knowledge, field of activity, industry in relation to the activity under analysis.

Let's assume that an expert group has already been formed and its members are familiarised with the purpose of the expert evaluation of candidate components for the formation or updating of the project portfolio (stages 1-3). The group's work is to rank the impact factors:

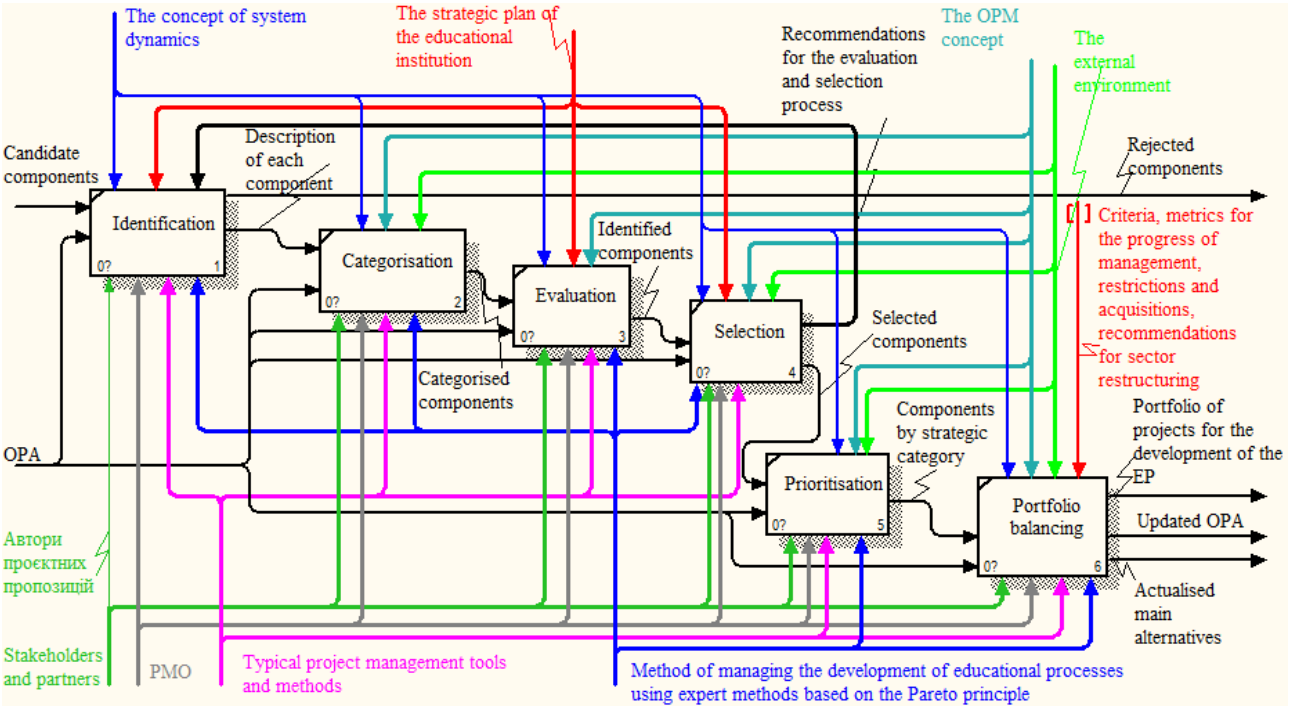

Fig. 3. **Diagram A0 of the top-level decomposition of the process "Formation of a portfolio of projects for the development of regional dual education"**

Source: **compiled by the authors**

The survey stage (4) is aimed at individual expert assessment of the impact of each project on each of the identified categories.

The results of the survey of all experts are presented in Table 2.

Table 2. **Results of the expert assessment for the group of project factors**

Factor	Experts				
	1	...	*j*	…	*m*
1	x_{11}	…	x_{1j}	…	x_{1m}
…	…	…	…	…	…
i	x_{i1}	…	x_{ij}	…	x_{im}
…	…	…	…	…	…
n	x_{n1}	…	x_{nj}	…	x_{nm}

***Source*: compiled by the authors**

where: x_{ij} is the assessment of the *i-th* project factor by the *j-th* expert;
n is number of impact factors for a particular category (group of indicators) of the project;
m is number of experts.

Stage of analysis and determination of the group expert assessment (5)

Summary of significance assessment y_i of each *i-th* project impact factor:

$$y_i = \frac{\sum_{j=1}^{m} x_{ij}}{n * m}, i = \overline{1,n}. \quad (1)$$

The assessment of a generalized project performance indicator, an example of which is yi, is most conveniently carried out on the basis of the preference function [28].

If the assessment uses a point system or indicator value $y_i \in [a,b]$ a uniform distribution is used as the preference function $r(y_i)$:

$$r(y_i) = \frac{y_i - a}{b - a}, a \le y_i \le b.$$

The closer the value obtained is to 1, the greater the number of experts who highly appreciated the importance of this factor. To include the influence factor in further research, it is necessary to select a threshold value of significance. The choice of the threshold value depends on the requirements for the quality of the innovation portfolio: the higher it is, the more stringent the requirements for the projects to be included in the portfolio.

The stage of synthesizing objective and subjective information to form a decision(6)

It is necessary to assess the intrinsic value of each project to be selected. The assessment is based on the selected criteria, and then a final score is calculated for the current state of the project.

The average score of the project's intrinsic value $\overline{v_l}$ is calculated if all criteria are equal:

$$\overline{v_l} = \frac{1}{n}\sum_{i=1}^{n} v_{li}, l = \overline{1,L}, \quad (2)$$

where: $\overline{v_l}$ – is the average score of the *l-th* innovative project;
n – the number of criterion features;
v_{li} – is the score of the *i-th* feature of the *l-th* innovative project.

Experts agree on a threshold for screening out innovative projects v_l^{lim}. A list of potential portfolio components whose integral values exceed v_l^{lim}.

The essence of the implementation of the method of portfolio formation and balancing

Will be considered according to the enlarged algorithm in accordance with the process model (see Fig. 3).

Identification of portfolio components
(process 1 of diagram A0 (see Fig. 3))

If there is a certain set of projects that should be included in the enterprise's innovation portfolio, it is necessary to conduct a qualitative and quantitative selection of projects. Qualitative selection can begin with placing projects in a matrix of combined criteria. Such a matrix can be created, for example, for a combination of profit-risk criteria (Fig. 4) or cost-benefit criteria.

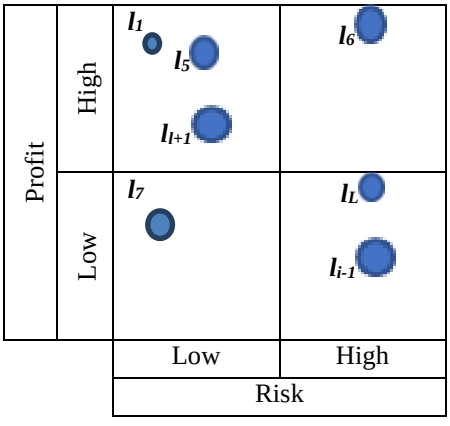

Fig. 4. **Matrix of project positioning according to the profit-risk criterion**
***Source:* compiled by the authors**

Some theoretical studies point out that, provided certain requirements are met, in most cases group ratings are more reliable than individual ratings [26], [27, 28]. For example, the distribution of scores obtained from experts should be "smooth", i.e. two group scores provided by two experts selected at random should be close. Thus, for each innovation project, the average score of its attractiveness $\overline{v_l}$ is calculated according to the expert method using formula (2).The diameter of the circles depends on $\overline{v_l}$ – the larger the diameter, the higher the project's attractiveness score.

The projects are reviewed by the degree of innovation complexity and grouped into groups that characterize the direction of project development depending on the phases of the innovation portfolio life cycle. The division of projects into groups allows balancing the portfolio by linking projects to the strategic development goals of the research object in a certain way. The probability of risk factors and the degree of their impact on project implementation can also be assessed by the selected group of experts. The degree of impact of risks on project implementation is assessed on a 10-point scale from safe (1 point) to fatal (10 points). The probability of risk occurrence is also expressed as a percentage, as a ratio of the number of possible project development options in which the risk will be affected.

There is a list of projects l_1, l_2 , ... l_L and some measurable outcome (profit), which is an additive function of the projects: *Profit* (l_1, l_2 , ... l_L) = *Profit* (l_1) + *Profit* (l_2) + ... *Profit* (l_L).

So, the *Pareto principle* states that:

1) There exists the following amount $0 < a < 0,5$, that projects can be divided into two groups P_1 and P_2 so that the size of the group $P_1 = a^* L$, and the result is *Profit* (P_1) = (1-a) * *Profit* (P_1, P_2),
that is, L-a of the total result of all projects;

2) And at the same time $a = 0,2$ (20 %) .

According to the Pareto principle, it can be argued that 20 % of innovative projects will ensure the development of the system by 80 % [29], [30]. At the same time, it is recommended to allocate no more than 20 % of resources to achieve long-term goals, which in our case are analogous to innovative projects financed from internal sources. This fact can be considered as one of the additional limitations of the process of forming a balanced portfolio of innovative projects of the enterprise. To finance other projects, it is suggested to start looking for external sources of funding. At the same time, it is necessary to take into account the time when the need for resources for a particular project arises. The planning of resource provision of the portfolio should be carried out in accordance with the established resource constraints, which are the limit that can be used for a particular project in a period.

3. APPLICATION OF THE DEVELOPED PROCEDURES FOR PLANNING THE PORTFOLIO MANAGEMENT OF THE DUAL EDUCATION SYSTEM

In accordance with the model for selecting innovative projects for the dual education development portfolio in the region, it is proposed to implement the model by conducting an expert evaluation of innovative projects.

On this basis, the following expert evaluation procedure is proposed:

1) Formulation of the purpose of the evaluation

For example, the purpose of the evaluation will be written as follows: "To obtain estimates of significance for all factors of the project's intrinsic value and select the most significant ones for further research".

2) Formation of a group of analysts to implement organizational measures and process the results

The process of identifying a circle of experts (related to this and the next stage 3) usually consists of identifying institutions that deal with project management, and later, each of the participants in the evaluation names a number of candidates from their circle of acquaintances. The formed group prepares materials for the study. Research participants get acquainted with the purpose and conditions of the study.

3) Selection of experts for the main examination

At this stage of the study, all project employees participate and the method of mutual evaluation is used, when the competence of a specialist is assessed by his or her colleagues. Based on the results of the survey, a matrix of mutual assessments is constructed, as shown in Table 3.

Based on the data obtained, the corresponding competence coefficient was calculated for each expert $0 < \alpha < 1$. The closer it is to 1, the more important is the opinion of this expert. To be included in the expert group, a threshold value of the competence factor is set. In our example, the minimum threshold value of is 0,5, which means that more than half of the experts surveyed consider

it necessary to include (In) this participant in the expert group (Table 4).

Table 3. **Matrix of mutual assessments of research participants**

		Experts						
		1	2	3	4	5	6	7
Experts	1	-	1	0	1	1	1	1
	2	1	-	0	1	0	0	1
	3	0	1	-	1	1	1	1
	4	1	1	1	-	1	0	1
	5	1	0	0	0	-	1	0
	6	1	1	1	0	1	-	1
	7	1	1	1	1	1	1	-

***Source*: compiled by the authors**

As shown in Table 2, the expert group for the research includes 5 participants who continue to work on ranking the influence factors.

Table 4. **Calculations of expert competence**

	Experts						
	1	2	3	4	5	6	7
α	0.7	0.3	0.7	0.7	0.4	0.7	0.9
In	yes	no	yes	yes	no	yes	yes

***Source*: compiled by the authors**

4) Conducting expert surveys

At this stage, experts are asked to give points from 1 to 7 in terms of the importance of the impact on each of the 4 categories: “Finance”, “Customers”, “Business Processes” and “Staff Training” of the proposed projects.

The degree of impact of the project on one of the 4 categories:

– is very important - 7;
– is important - 6;
– is quite important - 5;
– is not very important - 4;
– is of medium importance - 3;
– below average importance - 2;
– is of minor importance - 1.

The results of the ranking for the category “Finance” are presented in Table 5.

Of course, expert assessments sometimes include subjective opinions inherent in each expert, but these shortcomings are eliminated in the process of processing individual expert assessments. Similarly, the data on the results of the ranking of the importance of the influence factors for each category of the study (“Customers”, “Business Processes”, “Staff Training”) are recorded in the relevant Tabl. 6, Tabl. 7 and Tabl. 8.

Table 5. **Results of expert evaluation for the group of factors “Finance”**

Factor	Experts				
	1	2	3	4	5
F11.Net present value of the project	2	5	6	6	3
F12. Return on investment	5	3	3	4	4
F13. Internal rate of return on the project	6	5	2	1	2
F14. Modified rate of return on the project	3	4	3	4	2
F15. Discounted payback period of the project	6	5	5	6	5
F16. Revenue from new products	2	5	3	2	2

***Source*: compiled by the authors**

Table 6. **Results of expert assessment for the group of factors “Customers”**

Factor	Experts				
	1	2	3	4	5
F21. Increase in specialized employment	4	5	6	4	5
F22. Degree of satisfaction of stakeholders;	5	3	2	5	3
F23. Increase in the number of applicants	6	4	4	6	5
F24. Number of expelled students	3	4	3	4	2
F25. Price per year of study in comparison with competitors	3	5	2	3	5
F26. Number of class absences	5	2	3	2	3

***Source*: compiled by the authors**

Table 7. **Results of expert assessment for the group of factors “Business processes”**

Factor	Experts				
	1	2	3	4	5
F31. Execution of the project within the cost limits	4	5	6	5	3
F32. Research costs	2	5	3	2	2
F33. Availability of a database of employers	2	2	3	2	5
F34. Continuous improvement of product quality	2	4	3	4	3
F35. Time required to enter the market	3	5	2	3	5
F36. Execution of the project within the time limits	6	5	4	6	6

***Source*: compiled by the authors**

Table 8. **Results of the expert evaluation for the group of factors "Professional development of teachers"**

Factor	Experts				
	1	2	3	4	5
F41. Index of return on internal innovation compared to return on tangible assets	6	3	2	6	5
F42. Index of profitability of the i-th type of innovation	2	2	3	2	5
F43. Investment in training per customer	5	5	2	1	2
F44. The average length of service at the enterprise;	3	4	5	4	2
F45. Quality of knowledge management	5	6	4	4	6
F46. Opportunities for career growth	5	2	2	2	3

***Source*: compiled by the authors**

5) Processing and analysis of expert opinions

Summarized estimates of the significance of each of the impact factors for each project category are calculated using the formula (1).

The closer the value is to 1, the more experts highly rated the importance of this factor. To include an impact factor in further research, it is necessary to select a significance threshold. The choice of the threshold value depends on the requirements for the quality of the innovation portfolio: the higher it is, the more stringent the requirements for the projects to be included in the portfolio. The results are presented in Tabl. 9, Tabl.10, Tabl.11 and Tabl.12.

Table 9. **Significance of influence factors for the category "Finance"**

	Factors					
	F11	F12	F13	F14	F15	F16
y_i	0.76	0.63	0.53	0.53	0.9	0.46
y_i >0,75?	yes	no	no	no	yes	no

***Source*: compiled by the authors**

Table 10. **Significance of influence factors for the category "Customers"**

	Factors					
	F21	F22	F23	F24	F25	F26
y_i	0.8	0.6	0.83	0.53	0.66	0.46
y_i >0,75?	yes	no	yes	no	no	no

***Source*: compiled by the authors**

Table 11. **Significance of influence factors for the category "Business processes"**

	Factors					
	F31	F32	F33	F34	F35	F36
y_i	0.76	0.46	0.46	0.53	0.6	0.9
y_i >0,75?	yes	no	no	no	no	yes

***Source*: compiled by the authors**

Table 12. **Significance of influence factors for the category "Professional development of teachers"**

	Factors					
	F41	F42	F43	F44	F45	F46
y_i	0.73	0.46	0.5	0.6	0.83	0.46
y_i >0,75?	yes	no	no	no	yes	no

***Source*: compiled by the authors**

Thus, according to the examples in Tabl. 7, Tabl. 8, Tabl. 9 and Tabl. 10, the following factors of influence should be used for further research.

1. The category "Finance": net present value of the project and the discounted payback period of the project.

2. Category "Customers": Increase in specialized and Increase in the number of applicants.

3. "Business Processes" category: project execution within cost and project execution within time.

4. Category "Professional development of teachers": return on internal innovations compared to return on tangible assets and quality of knowledge management.

These factors are considered important by most experts and have a significant impact on the competitiveness of the innovation portfolio.

6) Synthesis of objective and subjective information to form a decision

According to the questionnaire, it is necessary to assess the intrinsic value of each project. The evaluation is based on the selected criteria, and then the final assessment of the current state of the project is calculated. Let's consider the case when 10 innovative projects are applying for inclusion in the portfolio. Each of the projects applying for inclusion in the portfolio is characterized by 8 selection indicators, which are grouped into four groups. According to the algorithm of the method, for each innovative project to be selected, the average score of the project's intrinsic value $\overline{v_l}$ (is calculated using formula (2), provided that all the criteria are equal. The results are presented in Table 13.

Table 13. **The initial set of projects to be included in the portfolio**

No. of innovative projects	Finance		Customers		Business Processes		Professional development of teachers		Average score of the educational project
	F11	F15	F21	F23	F31	F36	F41	F42	$\overline{v_l}$
1	2	3	3	1	2	4	2	3	2.63
2	2	2	3	1	1	1	1	2	1.88
3	5	3	4	3	3	4	3	3	3.88
4	4	3	3	1	1	1	1	2	2.50
5	1	2	3	5	1	1	6	5	3.63
6	5	2	4	6	5	5	4	4	5.13
7	3	2	1	1	2	2	3	2	2.88
8	5	5	3	5	5	4	5	5	5.63
9	5	3	2	5	4	4	4	1	4.63
10	3	4	4	1	2	2	3	1	3.75

***Source*: compiled by the authors**

In accordance with the threshold value of eliminating innovative projects at the level of three points established by the methodology, projects with numbers 1, 2, 4, 7, whose integral scores do not exceed 3 points should be excluded from further consideration.

The developed methodology has become an integral part of the practice of forming an innovation portfolio for the development of regional dual education (Dnipro). All projects were formalised using the Microsoft Office Excel spreadsheet editor. This choice is due to the fact that it is quite easy to integrate with most editors and databases, which greatly simplifies the further development of the software tool "System of support for the formation of an organisation's innovative project portfolio".

4. ALGORITHM FOR IMPLEMENTING THE METHOD OF FORMING AND BALANCING THE INNOVATION PORTFOLIO

For a holistic presentation of the essence of the implementation of the method of forming and balancing the innovation portfolio, an algorithm for the method of implementing the method is implemented in accordance with the process model "Formation of a portfolio of projects for the development of regional dual education" (Fig. 3).

Stage 1: Identification of portfolio Components

The results of ranking the candidate components of projects that should be included in the portfolio of dual education development projects are presented in Table 14.

Table 14. **The selected set of projects to be included in the portfolio**

No. of the Educational projects	Average score of the educational project
	$\overline{v_l}$
8	5.63
6	5.13
9	4.63
3	3.88
10	3.75
5	3.63

***Source*: compiled by the authors**

Potential portfolio components are analyzed for compliance with the organization's development strategy. Among the candidate components, qualitative and quantitative project selection is required. Qualitative selection can begin with placing projects in a matrix of combined criteria. Such a matrix can be created, for example, for a combination of profit-risk or cost-benefit criteria (Fig. 5).

Stage 2: Grouping of projects

Projects are considered by the degree of innovation complexity and grouped into groups that describe the direction of project development life cycle.

The division of projects into groups allows balancing the portfolio by linking projects to the strategic development goals of the research object in a certain way.

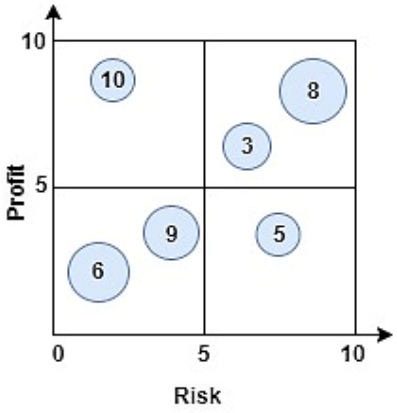

Fig. 5. **Matrix of project positioning in terms of profit-risk criterion**
***Source*: compiled by the authors**

The probability of risk factors and the degree of their impact on the project implementation is assessed by a group of experts. The degree of risk impact on project implementation is assessed on a 10-point scale from safe (1 point) to fatal (10 points). The probability of risk occurrence is also expressed as a percentage, as a ratio of the number of possible project development options in which the risk will be affected. According to Pareto's law, it can be argued that 20 % of innovative projects will ensure 80 % of the system's development [29, 30]. At the same time, it is recommended to allocate no more than 20 % of resources to achieve long-term goals, which in our case are analogous to innovative projects financed from internal sources. This fact can be considered as one of the additional limitations of the process of forming a balanced portfolio of innovative projects of the enterprise. To finance other projects, it is suggested to start looking for external sources of funding. At the same time, it is necessary to take into account the time when the need for resources for a particular project arises. The planning of the portfolio's resource provision should be carried out in accordance with the established resource constraints, which are the limit that can be used for a particular project in a given period. This approach is possible with the help of well-known software tools such as MS Project.

The above calculation algorithm determines the essence of the method of preparing information for managing the innovation portfolio of dual education development in the region. That is, the results obtained make it possible to form a holistic view of the process of collecting, analysis and preparation of information for strategic decision-making when balancing such an innovation portfolio. In the case of a large number of projects and programs to be selected for the portfolio, linear programming tools can be used.

CONCLUSIONS

1. In the PMI project portfolio management standard, portfolio formation is represented by a group of alignment processes, but their practical application in a specific subject area is left to the discretion of the developer. For the design and development of software systems, visual process models are developed for a specific subject area. Such visual models are developed in the article in the form of IDEF0 context diagrams.

2. A method for determining the priority set of innovative projects in the enterprise portfolio, taking into account funding constraints, is proposed, which allows, based on the ranking of projects, to make a decision and streamline the inclusion of each project in the innovation portfolio.

3. The method of competitive analysis of the portfolio components to form the composition of the innovation portfolio has been improved by applying expert methods.

4. On the basis of the developed methodology for forming a portfolio of innovative projects, the process of optimizing the efficiency of the portfolio of innovative projects on the basis of determining their individual priorities has been studied on the example.

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REFERENCES

1. “Monitoring the transparency of national higher education institutions”. CEDOS Centre (in Ukrainian). – Available from: http://www.cedos.org.ua/rating.– [Accessed: March, 2022].

2. “Consolidated ranking of Ukrainian universities: methodology” (in Ukrainian). *Education of Ukraine.* – Available from: http://osvita.ua/vnz/rating/25712. – [Accessed: March, 2022]

3. “The standard for portfolio management – fourth edition” (2017). – Available from: https://www.pmi.org/pmbok-guide-standards/foundational/standard-for-portfolio-management#. – [Accessed: March, 2021]

4. “The standard for program management”. Project Management Institute (Ed.). Newtown Square. Pennsylvania USA. 2017. 129 p.

5. Piterska, V. & Kramskiy, S. “Problems concept and differences between project, program and portfolio management”. *Management of Complex Systems Development.* 2017; 31: 6–12.

6. Wideman, R. M. “A comparison of project, program & portfolio management responsibilities – and who should be responsible for what. Differences between project, program and portfolio management” *Vancouver, BC*. 2014. p. 9–29.

7. Piterska, V., Lohinov, O. & Lohinova, L. “Portfolio method of scientific activity management of higher education institutions”. *Innovative Technologies and Scientific Solutions for Industries*. 2019; 2 (8): 86–96. DOI: https://doi.org/10.30837/2522-9818.2019.8.086.

8. Tian, Y., Bai, L., Wei, L., Zheng, K. & Zhou, X. “Modeling for project portfolio benefit prediction via a GA-BP neural network”. *Technological Forecasting and Social Change*. 2022; 183: 121939. DOI: https://doi.org/10.1016/j.techfore.2022.121939.

9. Molokanova, V. M. “Changes in portfolies management of organization projects in conditions of behavioral economy”. *Applied Aspects of Information Technology*. 2019; 2 (4): 345–358. DOI: https://doi.org/10.15276/aait.04.2019.8.

10. Molokanova, V. M. & Hordieieva, I. O. “Study of the organization adaptivity rate correlation in relation to its internal integrity”. *Herald of Advanced Information Technology*. 2020. 3 (4): 292–304. DOI: https://doi.org/10.15276/hait.04.2020.7.

11. Oganov, A. V. & Gogunskiy, V. D. “Necessity of implementing a project management office” (in Russian). *Information Technologies in Education, Science and Production.* 2013; 4 (5): 57–61.

12. Kharitonov, Y. N., Koshkin K. V. & Chernov S. K. “Model of dynamic management of project portfolio formation”. *Managing the Development of Complex Systems*. 2015; 13: 62–65

13. Lawrie, G. & Cobbold, I. "3rd generation balanced scorecard: evolution of an effective strategic control tool". *International Journal of Productivity and Performance Management*. 2004;. 53 (7): 611–623. DOI: https://doi.org/10.1108/17410400410561231.

14. Bushuiev, S. D. & Molokanova, V. M. “Formalization of the accounting valuable memes method for the portfolio of organization development and information computer tools for its implementation”. *Information Technologies and Learning Tools.* 2017; 62(6): 1–15.

15. Teslia, I., Khlevna, I., Yehorchenkov, O., Zaspa, H. & Khlevnyi, A. “The concept of integrated information technology of enterprises project activities management implementation”. In: *CEUR Workshop Proceedings.* 2021; 2851: 143–152.

16. Kozyr, S. V. & Molokanova, V. M. “Application of fuzzy evolutionary methods for the development of dual education projects”. *Herald of Advanced Information Technology*. 2022; 5 (4): 325–341. DOI: https://doi.org/10.15276/hait.05.2022.24.

17. Husieva, Y. Y. & Chumachenko, I. V. “Software for value monitoring as an adaptation tool for changes in project steakholders’ requirements” (in Ukrainian). *Radio Electronics, Computer Science, Control*. 2019; 4: 136–144. DOI: https://doi.org/10.15588/1607-3274-2019-4-13.

18. Kozyr, S. V., Slesarev, V. V., Us, S. A. & Khomyak, T. V. “Modeling and re-engineering of business processes” (in Ukrainian). *Dnipro University of Technology*. 2022. 163 p.

19. “A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Seventh Edition. Professional standard”. 2021.

20. Kozyr, S. & Sliesariev, V. “Algorithm for selecting and comparing of situations features of intelligent decision-making support system”. *11th International Conference on Advanced Computer Information Technologies, ACIT.* 2021. p. 657–661, https://www.scopus.com/authid/detail.uri?authorId=57288556600. DOI: https://doi.org/10.1109/ACIT52158.2021.9548528.

21. Korhonen, T., Jaaskelainen, A., Laine, T. & Saukkonen, N. “How performance measurement can support achieving success in project-based operations”. *International Journal of Project Management.* 2023; 41 (1): 102429 . DOI: https://doi.org/10.1016/j.ijproman.2022.11.002.

22. Yang, X., He, B., Wang, L., Yu, M. & Zhu, F. “Enabling projects for strategic implementation: Role of designated project manager in CEO-TMT interface during project front-end investment decisions”. *International Journal of Project Management*. 2021; 39 (6): 620–632. DOI: https://doi.org/10.1016/j.ijproman.2021.05.001.

23. Ponomarenko, V. S., Minukhin, S. V. & Znakhur, S. V. “Theory and practice of modelling business processes:monograph” (in Ukrainian). *KNEU*. Kharkiv: Ukraine. 2013. 244 p.

24 . Kozyr, S. V. “Computer-integrated system of support for managerial decision-making based on business processes”. *The Development of Technical Sciences: Problems and Solutions: Conference Proceedings* (in Ukrainian) . *Brno: Baltija Publishing*. 2018. p. 20–23.

25. Zhang, Z., Gao, J., Gao, Y. & Yu, W. *“*Two-sided matching decision making with multi-granular hesitant fuzzy linguistic term sets and incomplete criteria weight information”. *Expert Systems with Applications*. 2021; 168: 114311. DOI: https://doi.org/10.1016/j.eswa.2020.114311.

26. Liu, Y., Li, Yao, Liang, H. & Dong, Y. “Strategic experts’ weight manipulation in 2-rank consensus reaching in group decision making”. *Expert Systems with Applications*. 2023; 216: 119432. DOI: https://doi.org/10.1016/j.eswa.2022.119432.

27. Yaroshchuk, L. D., “Expert evaluation systems” (in Ukrainian). *Igor Sikorsky Kyiv Polytechnic Institute*. 2017. 40 p. – Available from: https://ela.kpi.ua/bitstream/123456789/19300/1. – [Accessed: March, 2020]

28. Mykhalev, O. I., Alpatov, A. P. & Baklan I. V., “Structural synthesis of project management systems” (in Rus.). *National Metallurgical Academy of Ukraine, IC “System Technology”*. Dnipro: Ukraine. 2013. 144 p.

29. Al-Najjar, N. I., Pomatto, L. “Aggregate risk and the Pareto principle”.*Journal of Economic Theory*.2020; 189: 105084. DOI: https://doi.org/10.1016/j.jet.2020.105084.

30. Serradell-Lopez, E., Lara-Navarra, P., & Martínez-Martínez, S. “The Pareto Principle in virtual communities of learning”. *Computers in Human Behavior*, 2023; 138: 107444. DOI: https://doi.org/10.1016/j.chb.2022.107444.

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Моделювання портфеля проектів регіонального розвитку дуальної освіти

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АНОТАЦІЯ

Метою статті є представлення методу управління портфелем проєктів для регіонального розвитку дуальної освіти в умовах невизначеності за допомогою експертних методів. У стандарті управління портфелем проєктів формування портфеля представлено групою процесів вирівнювання, але їх практичне застосування в конкретній предметній області залишається на розсуд розробника. Для проєктування та розробки програмних систем розробляються візуальні моделі процесів для конкретної предметної області. У статті представлено розробку комплексної системи дуальної освіти шляхом формування портфоліо проєктів. Отримані дані дозволили визначити, що методологія управління портфоліо може бути успішно впроваджена в українській дуальній освіті. Для вдосконалення процесів управління портфелем здійснено практичну реалізацію процесів формування портфеля в нотації IDEF0. Розроблено спрощений алгоритм формування портфоліо проєктів, що дозволяє збільшити швидкість реагування на зміни в управлінні портфоліо в освітній сфері.

Запропоноване рішення розвитку освітньої системи через портфоліо з використанням експертних методів, які відрізняються застосуванням правила Парето для побудови сценарію розвитку системи. На основі розробленої методології формування портфеля інноваційних проєктів на прикладі досліджено процес оптимізації ефективності портфеля інноваційних проєктів із визначенням їх індивідуальних пріоритетів. Продемонстровано застосування розроблених процедур планування управління портфоліо системи дуальної освіти в центральному регіоні України. Отримані результати дозволили переконатися, що управління розвитком системи в умовах неповної інформації охоплює сфери управління процесами та сприяє мінімізації впливу невизначеності на ефективність реалізації портфеля проєктів.

Ключові слова: Формування портфеля проєктів; матриця позиціювання проєктів; регіональна дуальна освіта; процесний підхід, експертний метод

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