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Conceptual model of sustainable development of pedagogical staff competences in quality assurance of higher education

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Creating strategies to improve the quality of higher education is the key task of higher education institutions in the conditions of rapid changes in the content of competencies, in particular IT-competencies, as well as in the conditions of turbulence in the external environment, in particular epidemics, military conflicts, etc. The article describes the conceptual model of sustainable development of teachers' competences in ensuring the quality of higher education in higher education institutions. The sustainability of the development of teachers' methodological competences is ensured by monitoring their activities based on the results of professional development and acquisition of the appropriate level of competence, as well as on the results of teaching by these teachers of relevant educational components in academic groups of higher education students. In order to reduce the risks of failing to pass the course, some participants of the competence project proposed to form a pool of potential project participants. Methods of optimization theory were used to solve the problem of selecting participants in the competence project. Also, the methodology of project management and pedagogical modeling was used to form the structure of the competence project and to plan its implementation. The assessment of methodological competences of university lecturers is crucial for building sustainable inter-university scientific and educational communities. Based on the results of the pilot implementation of the first stage of the competence project, project participants were selected on the basis of this conceptual model and training was organized to improve the level of competence in the field of education quality management. The results of training of teachers according to the described conceptual model allow to increase the level of their methodological competence. The obtained result requires clarification after completing the second stage of the competency-based project. Thus, the authors proposed an innovative approach to improving the level of competence of teachers of higher education institutions, which is focused on the effective assimilation of learning outcomes not only directly by teachers, but also by students of academic groups in which these teachers teach.

KEYWORDS

competence development, methodological competence, professional training, quality of higher education, multi-university community, competence project

1 Introduction

In recent decades, understanding the importance of education development for ensuring sustainable economic growth of the state has become essential. To improve the quality of education, educational initiatives are introduced, including those of international character, international educational projects are implemented, and competence projects are created, the purpose of which is to improve the level of knowledge and qualification of people working in the field of education. As it is known, the projects that are implemented in higher education institutions include the creation of educational programs, formation of human resources, construction and development of campus, etc. This paper will consider projects that aim to develop methodological competences of teachers to improve the quality of higher education. To ensure the effectiveness of such initiatives and effective implementation of competence projects, it is necessary to attract qualified participants motivated for professional development. The process of professional development and acquisition of methodological competences is complex and non-linear. Obtaining a certificate based on the results of professional development is only one dimension of quality assurance. To fully reflect the results of such professional development, it is necessary to monitor the participants' performance in the competence project after its completion. In practice, this rarely happens. To overcome this shortcoming of competence projects, it is necessary to formulate a framework that would allow teachers to assess the level of learning outcomes of their students based on the results of completing the learning of relevant educational components immediately after professional development.

The prerequisites for the study were the need to address the following problems:

- A significant gap between subject and methodological competence, insufficient general pedagogical training of current teachers, which is reflected in the uneven use of the competence-based approach,
- the need to improve the quality of teaching in organizations of higher and postgraduate education,
- the need to increase the importance of managing the professional development of teachers in the conditions of digitalization of society.

In general, ensuring the quality of teaching is directly related to the quality of teaching, and the quality of teaching in turn - to the continuous development of professional competence in general, methodological/didactic competence (as a component of professional competence).

Methodological competence includes a comprehensive set of abilities and skills that enable teachers to design, implement, and evaluate instructional strategies, materials, and activities, thereby facilitating meaningful and engaging learning experiences for students.

It is important to realize that the level of teacher competence can change during the development process and is not static. For quality teaching, the involvement of participants must be constant, especially in a turbulent environment. For this purpose, it is necessary to create a system of indicators, which are formed on the basis of testing students of the educational components that these teachers provide in their universities. It should be noted that the assessment of competences is formed based on the performance and productivity of teachers who have a certain level of competencies, and which are dynamically changing. Consequently, competence assessment also changes over time. In a turbulent external environment, such as war, epidemics, COVID-19 in particular, the process of maintaining the quality of higher education and ensuring the sustainability of competence development is particularly challenging. The process is also complicated by the rapid development of society and changes in the content of competences, in the field of information technology.

The idea of creating conceptual models of sustainable development of teachers' competences in ensuring the quality of higher education in higher education institutions, particularly in the context of environmental turbulence, is a vision that expands the theoretical knowledge in this direction. Sustainability of the development of methodological competences of teachers occurs through their monitoring of the results of professional development and acquisition of the appropriate level of competence, as well as the results of training of these teachers in relevant educational components in academic groups of higher education students. The described solutions should be designed and maintained during the life cycle of the competence project. For effective human resource management and development of teachers' competences in a higher education institution, a system should be developed, which should be integrated into the system of training of target groups of students of this higher education institution. Thus, the research of conceptual models of sustainable development of teachers' competences and strategies to improve the quality of higher education is actively conducted both at the level of higher education institutions and at the level of transformation and improvement of educational activities of the state.

Now there is no single interpretation of the term "methodological competence," but there is an understanding that competence is an objective condition that forms a common approach to actions, rights and responsibilities underlying the solution of specific tasks. Competence is a general characteristic of a person, reflecting internal qualities, a system of values and knowledge, allowing to find solutions to problems and contributing to professional growth. Some theoretical aspects of the formation of educational trajectories of competence development, particularly in IT, are described in Toxanov et al. (2024). At the same time, it should be noted that the key feature of ensuring the quality of higher education should be the orientation of students' learning. As described in Tigelaar et al. (2004), this requires somewhat different approaches to the formation of a framework of pedagogical or methodological competencies. Obviously, a new vision of the competence framework and the development of personality-oriented approaches to learning and teaching underlie changes in the system of assessing the level of competence mastery by teachers and students. The results of teachers' learning, and professional development should be supported by the results of students' learning. In Ellstrom and Kock (2008) it is argued that despite considerable interest in the topic of competence development, competence development has received little attention in the organizational environment, particularly in the university environment.

One of the solutions to improve the quality of competence acquisition by employees is to change the organizational structure of the company (Drejer, 2000). However, in higher education this structure is stable. Also, there is an advantage in getting feedback from students, i.e., teachers and students. In addition, it is possible to check the level of assimilation of teachers' competences almost immediately after training. This can be realized not only by testing the level of

knowledge, but also by the results of the students' assimilation of the knowledge of these teachers. That is, having undergone professional development, teachers can directly use their knowledge in practice.

The basics of the formation of teacher competences and criteria for controlling their level are described in Antera (2021), Yermolenko et al. (2020), and Aleksieienko-Lemovska (2022). Di Donato-Barnes et al. (2013), Niemi et al. (2019), and Cook and Hatala (2016) describe the practices of assessment and development of teachers' competencies. Many of these works present a clear vision of competence development, in particular digital competences, and do not take into account the possibility of involving students in the process of assessing the level of teacher competence. Biloshchytskyi et al. (2023) and Sharifbaeva et al. (2022) describe structural models of methodological competences development, as well as methods of their monitoring. This is important for ensuring the quality of higher education in higher education institutions. Abdullayeva (2022 describes the theoretical basis for the formation of methodological competence of teachers of higher education institutions considering the influence of the administration of educational institutions on this process. An important component of teachers' competence development is the use of active learning methods and the creation of a stimulating learning environment, in particular, the development of high-quality teaching materials and educational portals (Ouadoud et al., 2021; Tungpantong et al., 2021). The use of these materials and learning systems by teachers as well as knowledge modeling techniques are described in Schweizer et al. (2011) and Zhang et al. (2018).

In this study, the focus on quality assurance in higher education is on the project approach to competence development. That is, competence development is based on a competence project with its own structure and life cycle. For this project, performers or participants should be selected and they should have appropriate characteristics. Gogunskii et al. (2017) studies the system of project management in the educational sphere and the application of such a system in the work of higher education institutions. Xu et al. (2021) describes the task of selecting the executors of an educational project, which is generally similar to the task of selecting the participants of a competence-based project, but with an emphasis on the assessment of competencies. Effective selection of competence development project participants and project management is the key to the sustainability of competence development. In Hammer and Lewis (2023) the peculiarities of ensuring this stability in the activities of higher education institutions are described. In a turbulent environment, this stability can be disrupted due to the impact of many unpredictable negative factors on the education system. During the years of the COVID-19 epidemic, experience in adapting the education system and developing competences in distance learning has been accumulated (Sergeyeva et al., 2021; Trubavina et al., 2021; Myyry et al., 2022). Now in Ukraine there is a complex experience of adaptation of the education system in war conditions (Sibruk et al., 2023; Ma et al., 2022). Therefore, it is important to form a conceptual model of sustainable development of teachers' competencies, which would allow to ensure sufficient quality of education in the conditions of environmental turbulence.

Technology has transformed all aspects of life, including education, making its integration in learning essential. Many educational institutions now use technology to enhance teaching methods, giving students access to a wealth of resources and supporting more engaging learning experiences. This paper reviews secondary data to analyze the impact of modern technology in education, showing how tools like computers make information sharing easier for teachers and more accessible for students. The importance of technology in classrooms is clear—it enriches and simplifies the teaching and learning process (Ghory and Ghafory, 2021). Using digital modeling, software design, and theoretical analysis, along with a pedagogical experiment involving 86 students, an elective course titled "Physical Foundations of Tribology" was developed. Results indicate students gained strong professional creativity and readiness to use digital learning materials, with 75% demonstrating high professional competence (Nurizinova et al., 2024). The attitude of IT teachers toward their methodological development is investigated in Mukhatyev et al. (2024).

The results of studies on mentorship and teacher training for teaching are summarized in the metareview (Hoffman et al., 2019). The research identified four main areas: the structural features of mentoring experiences, the professional growth of future teachers during and after such experiences, and the factors influencing their development. The review emphasizes the potential of hybrid and innovative environments to transform teacher preparation, highlighting the impact of mentoring spaces on the sustainable development of educators. Challenges and prospects for further research in this field are also discussed. Velandia Mesa et al. (2019) focuses on rethinking and developing a conceptual approach to research competencies to strengthen educational research training. It shows that the primary challenges in research training include the gradual devaluation of experience, as well as the need for ethics, teamwork, integration of technology, and innovation. The research suggests incorporating formative research into educational programs as a tool for transformation and ensuring the quality of education. Schweizer et al. (2011) demonstrates that the structural organization of educational courses significantly impacts skill development, although differences between teaching teams or the temporal distance between courses did not have a substantial effect. Romero-García et al. (2020) argue that modern education requires active and participatory learning models that meet societal demands, particularly in the development of digital competencies. This study focused on the Common Framework for Teachers' Digital Competence (MCCDD) in Spain. The results showed significant improvement in all five areas of digital competence, emphasizing the importance of innovative practices in virtual classrooms to enhance the digital skills of future educators.

The reviewed studies highlight various approaches to the development of teachers' competencies, including digital skills, research training, mentorship, and literacy teaching. Common themes include the importance of integrating technology, ethics, innovation, and interdisciplinary collaboration in teacher preparation. These findings offer valuable directions for further development of global approaches to the sustainable growth of teaching competencies.

2 Materials and methods

To create a conceptual model of sustainable development of teachers' competences in ensuring the quality of higher education, legislative and regulatory documents on professional development in the Republic of Kazakhstan were analyzed, as well as scientific articles

in the direction of competences development of higher education teachers. Methods of optimization theory were used to solve the problem of selecting participants in the competence project. Also, the methodology of project management and pedagogical modeling was used to form the structure of the competence project and to plan its implementation. At the same time, from August 1 to August 28, 2024, Astana IT University monitored the process of training of competence project participants in the pilot part of its implementation.

Biloshchytskyi et al. (2023) the following three stages of improving methodological competence of teachers of IT disciplines were defined: initial, theoretical and practical, and practical. Therefore, the methods in the work were divided into three components. The first stage is the stage of forming a team of competence project participants based on the results of the input diagnostics of the competence level of potential participants. At the second stage, the project participants are directly trained in accordance with the described concept. The third stage is the implementation stage, where, according to the concept, students of academic groups in higher education institutions should study and evaluate the level of assimilation of learning outcomes. Moreover, the participants of these academic groups are participants in a competence-based project. Ensuring the sustainability and continuous development of such a project under conditions of rapid changes in the IT industry as well as environmental turbulence (martial law, pandemic) is the key to improving the quality of higher and postgraduate education. Toxanov et al. (2024) described the results of the implementation of the IT competence development information system. The conceptual model of sustainable development of teachers' competences in ensuring the quality of higher education described in this paper will be integrated into this information system at Astana IT University.

3 Results

3.1 Established model for the development of teachers' competences in the activities of higher education institutions

The development of higher education teachers' competences can be considered as a project. A project is a purposeful formation of a set of activities aimed at achieving a certain goal, considering the limitations of time, human and financial resources. Considering the goal of competence development in higher education institutions through the prism of project activities allows applying the necessary mechanisms and methodology of project management to achieve the planned goal. The project providing for the development of competence of teachers and students in higher education institutions will be called a competence project.

Let us build a given model of the competence project life cycle that defines the different stages of its development from formation to completion. The main stages of the competence project life cycle are planning, development, implementation, operation and maintenance, evaluation and improvement. For example, if the goal of a department of a higher education institution is to improve the delivery system of educational programs through the training of qualified personnel. In this case, the life cycle of such a project starts with the planning of the competence development program and its writing, and ends with evaluation and improvement, for example, as a result of accreditation of the educational program or testing the knowledge of the project participants.

An important stage of the life cycle, which sets the main trend in the project development, is planning, which sets the goal of the project, as well as determines the human, time and financial resources required for the project realization. Development of a competence project implies creation of educational content, creation of educational programs and training materials, provision of technical support, in particular, creation of a website, software and setting up a training platform, etc. The realization of the competence project is the launching stage and the beginning of the educational process. Based on the results of the training, an efficiency assessment is carried out, i.e., a determination of how effectively the competence project is implemented in terms of achieving the set goal and objectives. After implementation, requirements are formed to ensure sustainable operation of the competence project, to provide support to users and participants of the project. In the lifecycle of a competence project, it is important to ensure its continuous improvement. This is since changes occur very quickly, and the competence project must respond quickly to this by improving the training program and making changes to the competence matrix, in particular IT components that are formed in the trainees.

Let $U = (U_1, U_2, \ldots, U_m)$ is a list of higher education institutions realizing competence projects, and m – is a number of higher education institutions. Then we denote $\Theta^i = \left(O_1^i, O_2^i, \ldots, O_{n_i}^i\right)$ by competence projects that are being implemented or are being implemented in a higher education institution $U_i, i = \overline{1,m}$ is a number of competence projects in a higher education institution. We also capture projects that have already been completed, as their number and ratings can be used to evaluate the performance of higher education institutions U_i. We also define discrete time $T = (t_0, t_1, \ldots, t_r)$ and assume that competence projects transform over time as they move from one state to another. Let us define the following states of a competence project: planning stages (E_p), development stages (E_d), implementation stages (E_w), operation and support stages (E_s), and completion stages (E_x).

At each moment of time $t_k \in T$ each competence project belongs to one of the stages (states of the life cycle), and at certain moments of time there is a transition of the competence project from one state to another. The first state (planning stage) is the initial state, i.e., the project is not in any state before this state. The last state (completion stage) is the final state, i.e., the facility project does not transition to another state after this state. All projects that fall within this state are the history of the higher education facility project and can be used to evaluate it (Figure 1). There can be a transition of projects between the development, implementation, operation, and maintenance phases. In other words, if a competence project needs refinement in the implementation and support stage, it moves to the development stage and is refined and then implemented and operated (Figure 2). If it is not possible to improve the project, the project is moved to the refinement stage and a new project is created at the planning stage. If we talk about IT competence development in higher education institution, such plasticity of competence project realization is important precisely because of the rapid changes in IT industry, which need to be clarified in the process of realization of the corresponding competence project. In other words, change management in the competence project is the key to ensure its effectiveness.

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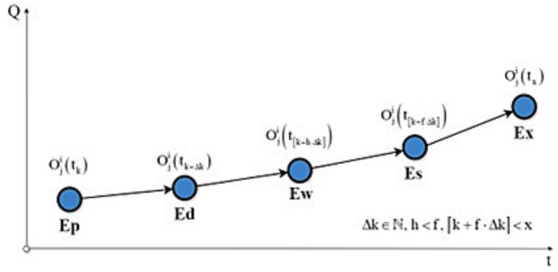

FIGURE 1
Diagram of the stages of the life cycle of competence projects and their transformation.

Formally, a higher education institution $U_i, i=\overline{1,m}$ in time $t_k \in T$ is defined by the competence profile of the projects that have been implemented in it or have been implemented before the time t_k, i.e., have been implemented in the time interval $[t_o, t_k]$. The profile of competence projects of a higher education institution is defined by five tuples, where the upper index above the letter j indicates that the projects are at the corresponding stage of the competence project life cycle:

$$O^i(E_p,t_k)=\left(O^i_{j_1^p},O^i_{j_2^p},\ldots,O^i_{j_p^p}\right),\ j^p_{b_1}\in\{1,2,\ldots,n_i\},\ b_1=\overline{1,p},$$

$$O^i(E_d,t_k)=\left(O^i_{j_1^d},O^i_{j_2^d},\ldots,O^i_{j_d^d}\right),\ j^d_{b_2}\in\{1,2,\ldots,n_i\},\ b_2=\overline{1,d},$$

$$O^i(E_w,t_k)=\left(O^i_{j_1^w},O^i_{j_2^w},\ldots,O^i_{j_w^w}\right),\ j^w_{b_3}\in\{1,2,\ldots,n_i\},\ b_3=\overline{1,w},$$

$$O^i(E_s,t_k)=\left(O^i_{j_1^s},O^i_{j_2^s},\ldots,O^i_{j_s^s}\right),\ j^s_{b_4}\in\{1,2,\ldots,n_i\},\ b_4=\overline{1,s},$$

$$O^i(E_x,t_k)=\left(O^i_{j_1^x},O^i_{j_2^x},\ldots,O^i_{j_x^x}\right),\ j^x_{b_5}\in\{1,2,\ldots,n_i\},\ b_5=\overline{1,x}.$$

If $E=\{E_p,E_d,E_w,E_s,E_x\}$ is a set of all stages of the project competence lifecycle, so $\Theta^i=\bigcup_{e\in E}O^i(e,t_k)$ Θ^i is time-independent. Let us consider the cases that can be in the system of project competence lifecycle movement:

1 Transfer of competence project from state E_s to state E_d (Figure 2).
2 Finalize the competence project, i.e., send the project to the state E_x (Figure 3).
3 Begin planning a new competence project, i.e., bring the new project to the state E_p (Figure 4).

The figures below show diagrams of the stages of the competence project life cycle, with these stages starting at specific points in time and may have numerical estimates of implementation effectiveness.

3.1.1 Case 1

If at one point in time $t_{k+1}\in T$ is a composite project for a higher education institution U_i, $i=\overline{1,m}$ which is in operation $O^i_{j_y^s}$ and maintenance and requires some changes, the competence profile of higher education institution projects will be defined as follows:

- $O^i(E_p,t_{k+1})=\left(O^i_{j_1^p},O^i_{j_2^p},\ldots,O^i_{j_p^p}\right),\ j^p_{b_1}\in\{1,2,\ldots,n_i\},\ b_1=\overline{1,p},$
- $O^i(E_d,t_{k+1})=\left(\overset{\sim i}{O^i_{j_1^d}},O^i_{j_2^d},\ldots,O^i_{j_d^d},O_{j_{d+1}^d}=O^i_{j_y^s}\right),$
  $j^d_{b_2}\in\{1,2,\ldots,n_i\},\ b_2=\overline{1,d+1},$
- $O^i(E_w,t_{k+1})=\left(O^i_{j_1^w},O^i_{j_2^w},\ldots,O^i_{j_w^w}\right),\ j^w_{b_3}\in\{1,2,\ldots,n_i\},\ b_3=\overline{1,w},$
- $O^i(E_s,t_{k+1})=\left(O^i_{j_1^s},O^i_{j_2^s},O^i_{j_{y-1}^s},O^i_{j_{y+1}^s},\ldots,O^i_{j_s^s}\right),\ j^s_{b_4}\in\{1,2,\ldots,n_i\},$
  $b_4=\overline{1,s},\ b_4\neq y,$
- $O^i(E_x,t_{k+1})=\left(O^i_{j_1^x},O^i_{j_2^x},\ldots,O^i_{j_x^x}\right),\ j^x_{b_5}\in\{1,2,\ldots,n_i\},\ b_5=\overline{1,x}.$

We add the competence project $O_{j_{d+1}^d}=O^i_{j_y^s}$ to the second tuple, while removing it from the fourth one.

3.1.2 Case 2

If at some point in time $t_{k+1}\in T$ for a higher education institution U_i there is a competence project $i=\overline{1,m}$, $O^i_{j_y^s}$ which is in operation and cannot be continued, it is removed from the cycle, including in the tuple E_x, i.e.:

- $O^i(E_p,t_{k+1})=\left(O^i_{j_1^p},O^i_{j_2^p},\ldots,O^i_{j_p^p}\right),\ j^p_{b_1}\in\{1,2,\ldots,n_i\},\ b_1=\overline{1,p},$
- $O^i(E_d,t_{k+1})=\left(O^i_{j_1^d},O^i_{j_2^d},\ldots,O^i_{j_d^d}\right),\ j^d_{b_2}\in\{1,2,\ldots,n_i\},\ b_2=\overline{1,d}$
- $O^i(E_w,t_{k+1})=\left(O^i_{j_1^w},O^i_{j_2^w},\ldots,O^i_{j_w^w}\right),\ j^w_{b_3}\in\{1,2,\ldots,n_i\},\ b_3=\overline{1,w},$
- $O^i(E_s,t_{k+1})=\left(O^i_{j_1^s},O^i_{j_2^s},O^i_{j_{y-1}^s},O^i_{j_{y+1}^s},\ldots,O^i_{j_s^s}\right),\ j^s_{b_4}\in\{1,2,\ldots,n_i\},$
  $b_4=\overline{1,s},\ b_4\neq y,$
- $O^i(E_x,t_{k+1})=\left(O^i_{j_1^x},O^i_{j_2^x},\ldots,O^i_{j_x^x},O^i_{j_{x+1}^x}=O^i_{j_y^s}\right),$
  $j^x_{b_5}\in\{1,2,\ldots,n_i\},,\ b_5=\overline{1,x+1}.$

3.1.3 Case 3

If at a point in time $t_{k+1}\in T$ for a higher education institution U_i, $i=\overline{1,m}$ is necessary to start planning a new competence project, it is included in the tuple E_p, i.e.:

- $O^i(E_p,t_{k+1})=\left(O^i_{j_1^p},O^i_{j_2^p},\ldots,O^i_{j_p^p},O^i_{j_{p+1}^p}\right),$
  $j^p_{b_1}\in\{1,2,\ldots,n_i\},\ b_1=\overline{1,p+1},$
- $O^i(E_d,t_{k+1})=\left(O^i_{j_1^d},O^i_{j_2^d},\ldots,O^i_{j_d^d}\right),\ j^d_{b_2}\in\{1,2,\ldots,n_i\},\ b_2=\overline{1,d}$
- $O^i(E_w,t_{k+1})=\left(O^i_{j_1^w},O^i_{j_2^w},\ldots,O^i_{j_w^w}\right),\ j^w_{b_3}\in\{1,2,\ldots,n_i\},\ b_3=\overline{1,w},$
- $O^i(E_s,t_{k+1})=\left(O^i_{j_1^s},O^i_{j_2^s},\ldots,O^i_{j_s^s}\right),\ j^s_{b_4}\in\{1,2,\ldots,n_i\},\ b_4=\overline{1,s},$
- $O^i(E_x,t_{k+1})=\left(O^i_{j_1^x},O^i_{j_2^x},\ldots,O^i_{j_x^x}\right),\ j^x_{b_5}\in\{1,2,\ldots,n_i\},\ b_5=\overline{1,x}.$

It should be noted that this conceptual model can be detailed more deeply, since each of these stages includes a certain number of stages, depending on the specifics of the competence project. But since

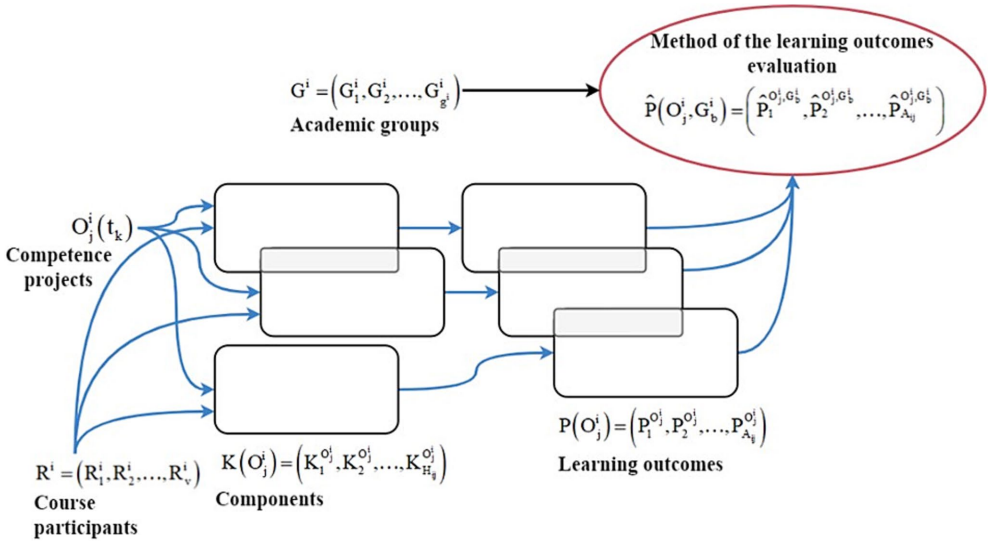

FIGURE 2
Scheme of project transition between life cycle stages and improvement of project competencies.

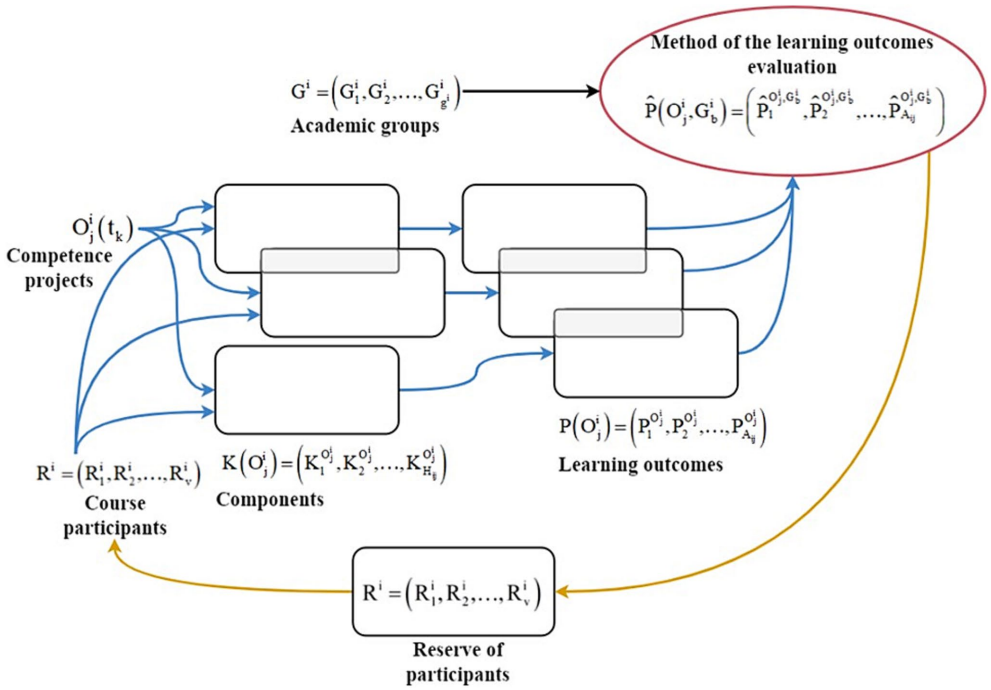

FIGURE 3
Scheme of implementation of projects based on competences that are in the process of implementation.

each corporate project is unique, such deep detail does not have a tangible effect on the success of the project but is only a guide for the project manager. The competence project manager uses a common traditional scheme or forms its own scheme and adapts existing schemes to the needs of a specific competence project.

Let us look at a general scheme that will help the manager to detail the conceptual framework for a specific competence project. At the first stage, it is necessary to determine the purpose and objectives of the competence project for the development of Human Resource competences of a specific educational organization, particularly a higher educational institution. The goals and objectives of the project should be achievable, measurable, realistic and have a clear time frame. Within the framework of the set goals and objectives, it is necessary to analyze and describe the participants of the course and the participants of academic groups. It is necessary to specify your age, level of education, interests and other necessary characteristics. Students of the courses are the human resources of a higher educational institution, which increases the level of competence, in

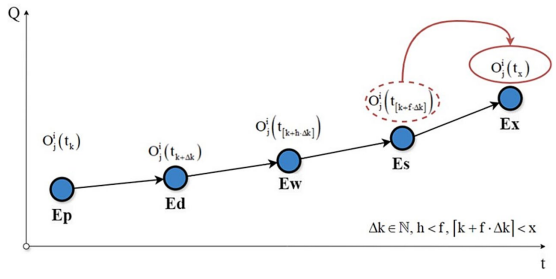

FIGURE 4
Scheme for adding new competence projects.

particular in its field. Academic groups are formed from interested persons who are students or students of higher educational institutions and who will be taught by participants who have already improved their competence.

For each task of the project, a time frame is set, and an estimate is formed, a description of the needs for material and human resources, and so on. To complete the project, you need to create educational content that can be placed in a specific LMS. The progress and results of the project are monitored, as well as the criteria for its implementation are determined. It is also important to ensure stable communication between course participants and other interested groups during the implementation of a computer project. A risk management strategy is also being formed to prevent undesirable situations, as well as identify problems that may arise during the project implementation process. After the completion of the project and the training of students of academic groups, the impact of the project is assessed at the local level (the assimilation of knowledge by participants and students) and at the institutional level (the development of the quality of teaching in higher education). The implementation of the competence project is a critical stage, after which the plan is transformed into an educational program that is used for human resources or employees of a higher educational institution, which in turn trains students.

For each point in time, each higher education institution must define a list of project competencies. Certain projects are under implementation, certain projects are under development, development and so on. At the same time, if you use the described general scheme of the life cycle of the competence project, then you can make changes to a specific project, considering its features and structure. Let there be a description of competence projects $\Theta^i = \left(O_1^i, O_2^i, \ldots, O_{n_i}^i\right)$ for higher education institutions $U = \left(U_1, U_2, \ldots, U_m\right)$.

Competence projects are the basis of educational, scientific or professional training programs for primary higher education institutions. In this regard, the tasks or components of competence projects are the disciplines that are taught within the framework of these programs. These components may or may not overlap. Also, based on the results of training, learning outcomes are formed, which can also overlap each other. Upon receipt of competence projects, a list of course participants is formed from among the scientific, pedagogical or administrative staff of higher educational institutions. $R^i = \left(R_1^i, R_2^i, \ldots, R_v^i\right)$ - a list of potential project participants or scientific and pedagogical staff of a higher educational institution U_i that R_k^i are potential participants of a higher educational institution U_i.

Let us denote $K = \left(K_1, K_2, \ldots, K_H\right)$ as a list of components of the competence project, where H - number of components of the competence project is indicated.

Then we will designate $K\left(O_j^i\right) = \left(K_1^{O_j^i}, K_2^{O_j^i}, \ldots, K_{H_{ij}}^{O_j^i}\right)$ as a list of components of the competence project O_j^i of a higher educational institution U_i, $i = \overline{1,m}$, $j = \overline{1,n_i}$, H_{ij}—this is the number of components of the competence project O_j^i.

We also use $P = \left(P_1, P_2, \ldots, P_A\right)$ to indicate the list of learning outcomes in a competence project and A—the number of learning outcomes in a competence project. $P\left(O_j^i\right) = \left(P_1^{O_j^i}, P_2^{O_j^i}, \ldots, P_{A_{ij}}^{O_j^i}\right)$—list of learning outcomes of the competence project of a higher educational institution U_i $j = \overline{1,n_i}$, $i = \overline{1,m}$, A_{ij} is the number of components of the educational project O_j^i.

The assessment of learning outcomes can be assessed for an academic group of students, which is determined by a specific target group. If the higher education institution U_i, g^i represents academic groups $G^i = \left(G_1^i, G_2^i, \ldots, G_{g^i}^i\right)$, is an academic group of students or university students U_i, $b = \overline{1, g_i}$.

So,

$$\hat{P}\left(O_j^i, G_b^i\right) = \left(\hat{P}_1^{O_j^i, G_b^i}, \hat{P}_2^{O_j^i, G_b^i}, \ldots, \hat{P}_{A_{ij}}^{O_j^i, G_b^i}\right), \quad (1)$$

where $\hat{P}_f^{O_j^i, G_b^i}$ – the average assessment of the development of the program $f = \overline{1, A_{ij}}$ The result of an educational project or program O_j^i of academic group U_i at university G_b^i, $b = \overline{1, g_i}$, $j = \overline{1, n_i}$ $i = \overline{1, m}$.

Thus, a conceptual diagram of the relationship between the components or tasks of a competence project, participants, and learning outcomes can be shown in Figure 5.

Thus, as can be seen from Figure 5, the participants of the competence project are redistributed between the educational components of the competence programs. Specific learning outcomes are associated with each educational program. Further, based on the results of the application of the methodology for evaluating the learning outcomes of a competitive academic group in which the project participants teach by competence, we can talk about the professional assessment of the project participant. The assessment of the project participants should be transparent, independent and reliable. The average score based on the results of training is calculated based on Table 1 for the corresponding group by testing or examining all students in the academic group and averaging the results. This indicator is an assessment of the assimilation of learning outcomes and, accordingly, an assessment of the scientific and pedagogical staff or a project participant who is assigned an appropriate educational component, the result of which is the corresponding learning outcomes.

Accordingly, the relationship between the educational components and the participants of the competence project is functionally defined as follows:

$$F : R_1^i \times R_2^i \times \ldots \times R_v^i \to K_q^{O_j^i}, q = \overline{1, H_{ij}}, j = \overline{1, n_i}, i = \overline{1, m} \quad (2)$$

The relationship between educational components and learning outcomes is functionally defined as follows:

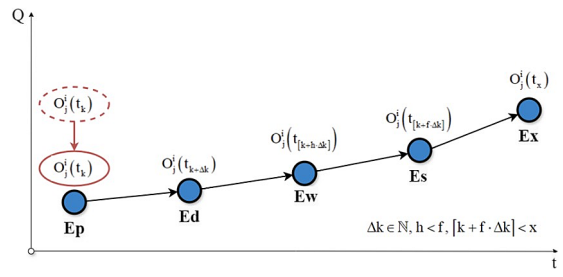

FIGURE 5
A diagram of the relationships between the components or tasks of the competence project, participants, learning outcomes, etc.

TABLE 1 The scale of evaluation of learning outcomes.

Evaluation interval	Interpretation of estimates
A-(90.100]	Excellent mastering of learning outcomes
B-(75.90]	Good learning outcomes during mastering
C-(60.75]	Satisfactory mastering of learning outcomes
D-(50.60]	Mastering the learning outcomes at the minimum passing level (depending on the testing system, it can be included in the passing result or not)
E-(10.50]	Poor learning outcomes
F-(0.10]	Ultra-low result. Repeat the course

$$D: K_1^{O_j^i} \times K_2^{O_j^i} \times \ldots \times K_{H_{ij}}^{O_j^i} \to P_f^{O_j^i} f = \overline{1, A_{ij}}, j = \overline{1, n_i}, i = \overline{1, m} \quad (3)$$

Such a connection between the components and the result of the project requires constant training of scientific and pedagogical staff or participants in a competence project to increase the level of competence in a certain educational component, which is already included in educational programs on the basis of which the relevant academic groups of university students are trained. In this case, a violation of the process of attracting participants to the competence project may interfere with the timely and effective implementation of the project objectives. To reduce the risks in this case, it is possible to build a model for the formation of a working group of participants in the competence project.

3.2 A model for the formation of a working group of participants in the project of competences of a higher educational institution

It is possible to formulate a hypothesis that the higher the effectiveness of the project, the more effectively the recruitment of project participants and their training in relevant competences are determined. Let us formulate a mathematical model for selecting potential project participants by competence. If $R = (R_1, R_2, \ldots, R_v)$– a list of potential project participants or scientific and pedagogical staff of a certain higher educational institution. Let us $K = (K_1, K_2, \ldots, K_H)$ is a set of components of the competence project, in which the project participants should be involved. If $C = \{c_{ij}\}_{i,j=1}^{v,H}$ - the competence matrix of potential participants in the competence project is related to the relevant educational components. An integral matrix of values will also be defined, linking the cost of training a potential contractor according to the competences of the relevant educational component of the project $D = \{d_{ij}\}_{i,j=1}^{v,H}$. If $d_{ij} > 0$, then the participant R_i of the competence project studies the competence of the component K_j and receives the appropriate competencies. If the participant R_i is not studying educational competence K_j, then $d_{ij} = 0$. We will also set a limit on the number of performers who can study this educational competence: L_j, $j = \overline{1, H}$.

It is necessary to select the participants to study all the educational components of the competence project. Participants may be employees of a particular higher education institution, as well as other universities or scientific institutions. The level of detail of the model depends on this.

In a simple case, the matrix of competence project participants is a Boolean matrix $S = \{s_{ij}\}_{i,j=1}^{v,H}$, $s_{ij} \in \{0,1\}$. If $s_{ij} = 1$ a potential participant is a participant R_i in a competence project and studies the educational component K_j. If $s_{ij} = 0$ then the potential participant R_i does not study the educational component K_j. Next, the task has the form:

$$\sum_{i=1}^{v} \sum_{j=1}^{H} s_{ij} d_{ij} \to \min, \quad (4)$$

$$\sum_{i=1}^{v} s_{ij} \geq L_j, j = \overline{1, H}, \quad (5)$$

$$\sum_{j=1}^{H} s_{ij} c_{ij} = 1, i = \overline{1, v} \quad (6)$$

In general, this problem is relatively easy to solve. However, if the educational project has a complex structure, with a large number of connections, it will be difficult to find a solution for this problem. If we denote via $R_f^i \subseteq R^i$ by a subset of the set of competence project participants for a higher education institution U_i, $i = \overline{1, m}$. Let $\hat{P}_f^{O_j^i, G_b^i}(R_f)$, $f = \overline{1, A_{ij}}$ is the average assessment of learning outcomes that refer to such educational components for which the participants belonging to the subset $R_f^i \subseteq R^i$are responsible. If $K_f^i \subseteq K^i$- a subset of these educational components that belongs to the set of all components of a higher education institution $U_i, i = \overline{1, m}$ then we obtain the problem of maximizing the mean value of learning outcomes scores:

$$\frac{1}{f} \sum \hat{P}_f^{O_j^i, G_b^i}(R_f) \to \max \quad (7)$$

where f is the number of learning outcome assessments.

The peculiarity of competence-project teams formation is that one and the same participant can be a member of several competence-projects simultaneously. Let $R(O_j^i) = (R_1^{ij}, R_2^{ij}, \ldots, R_{v_{ij}}^{ij})$ is a set of competence-project participants or a working group of project participants, and

$$R(O_j^i) \cap R(O_k^i) = \varnothing \text{ or } R(O_j^i) \cap R(O_k^i) \neq \varnothing \quad (8)$$

To simplify the reasoning, let us assume that $R\left(O_j^i\right) \cap R\left(O_k^h\right) = \varnothing$. In other words, the project implementer is affiliated with only one higher education institution.

An important step in ensuring the effectiveness and sustainability of a competence-based project is to continuously monitor the performance of the human resources of a higher education institution to involve them in the competence-based project at certain stages of its lifecycle. This process helps to determine team performance, identify opportunities for improvement, and ensure that project goals are met. The key aspects of performance monitoring and evaluation are quantitative and qualitative KPIs. In other words, identify specific metrics that can be used to measure performance, such as the number of tasks completed on time, the quality of work completed, the satisfaction level of participants, and so on. To monitor effectively, performance evaluation systems should be put in place to capture different aspects of performance, to ensure objectivity and regularity of evaluation. In addition, since the functioning of the system can take place under conditions of external environment turbulence, which affects the achievement of results, it is necessary in the concept to provide for the formation of the so-called reserve of performers, which will be selected by scientific and pedagogical staff. Figure 6 presents a diagram of interrelationships between components or tasks of the project by competence, participants, learning outcomes, etc. considering the pool of potential project participants.

The conceptual model of the competences project (Equations 1–8) was adapted and used during the implementation of the project, which was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (see section "Funding"). The studies involving humans were approved by The Committee on Research Ethics, Astana IT University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The survey was conducted online, which ensured the requirement of anonymity. At the first stage of the project the selection of participants was conducted to improve the level of competence in the organization of work and quality management of higher education provision. The participants were represented by teachers, researchers, managers and heads of more than 40 higher education institutions of the Republic of Kazakhstan. Based on the results of the selection, a training session was organized in Astana IT University (Astana, Republic of Kazakhstan) from 1 to 28 August 2024. A total of 95 people participated in the training sessions. Depending on the level of education, Masters, PhDs, postgraduates participated in the training. The distribution of participants by gender was uneven, including about 20% of men and 80% of women. The aim of the training was to develop competences in the field of quality management in higher education, to build an internal quality assurance system, to improve the efficiency of higher and postgraduate education. At the second stage of the project implementation, according to the described concept. It will be ensured that the competences acquired by the project participants will be disseminated among academic groups of higher education institutions. The concept is currently undergoing pilot implementation, but already at the initial stages of its realization successful results are known. Out of 95 participants, all 95 have completed the training. The distribution of the level of training results on the scale (Table 1) for this group is tentative: A—15% of participants, B - 30% of participants, C—45% of participants, D—10% of participants. The obtained result requires clarification after completing the second stage of the competency-based project.

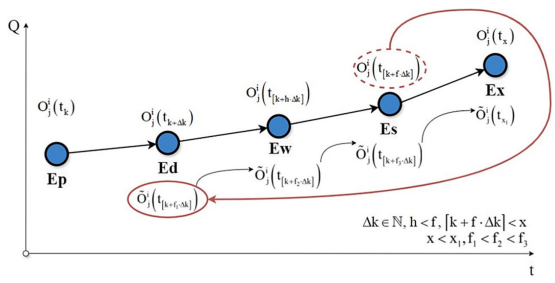

FIGURE 6
Diagram of interrelationships between components or tasks of the competence project, participants, learning outcomes, etc., taking into account the pool of potential project participants.

Since this concept is planned to be implemented not only in the Republic of Kazakhstan, but also in other countries, it is important to understand under what conditions this implementation is possible and to anticipate possible risks.

4 Discussion

The selection of instructors for teaching specific disciplines, considering their level of methodological competence and characteristics, may be accompanied by a number of limitations and challenges. The first significant limitation is the subjectivity of assessing competence levels, especially when the evaluation criteria are vaguely defined. When involving expert opinions, there is a challenge in reconciling differing views of experts regarding the importance of specific competencies for a given discipline.

Another difficulty is the shortage of qualified personnel. Some universities face a demand for professional instructors who can ensure the operation of specific educational programs. However, these instructors may be engaged at other universities or located in other countries, while retraining and upskilling other instructors require time and resources. Therefore, it is necessary to develop an evaluation system that could facilitate the formation of sustainable inter-university educational and scientific communities.

The issue of engaging professional instructors could also be addressed by implementing systems of distance learning for specific disciplines or ensuring academic mobility. Additionally, it is important to maintain a balance between instructors' methodological competence and their practical experience. Instructors with significant practical experience in their field may be less competent from a methodological perspective. On the other hand, highly qualified methodologists may sometimes lack sufficient real-world experience in the field they teach. For this reason, an approach to evaluating methodological competence must be developed that takes this balance into account.

The described conceptual model of the relationship between project competences is particularly relevant in the context of environmental turbulence. The turbulence of the external environment can manifest itself in the conditions of martial law (due to the martial law in Ukraine) and pandemic (COVID-19). Because in these

conditions the implementation of competence projects requires a special approach and consideration of several factors that can affect the ability of the team to work and achieve the set goals. The use of remote approaches to work and the complexity of the tasks involved in recruiting staff, etc., are also special features.

Particularly in a martial law environment, the safety and integrity of employee information and the security of the employees themselves or the employee of a composite project is important. It is important to conduct a detailed analysis of potential threats and risks to ensure the safety of the trainee team members and competence project implementers. In case of a breach of requirements, it is necessary to implement the competence project in a remote format. Another important aspect of working in such conditions is to ensure a high level of confidentiality and protection of personal data of the project participants. As significant losses in communication and power supply occur, it is important to ensure availability and reliability of working tools and communication infrastructure even under uncertain conditions. It is necessary to take into account the possibility of using secure information communication tools that can ensure sustainable communication in case of loss of backbone channels. Under martial law, it is important to create flexible strategies and plans that can be quickly adapted to changes in the situation, identify mechanisms for knowledge retention and transfer in case of loss of key actors. Therefore, in the event of this type of turbulence, it is important to create a reliable safe pool of potential project participants who can be called upon to perform tasks at any desired time.

In a pandemic environment, remote working and remote communication are important aspects of implementing competence projects: use of virtual platforms, engagement and integration of virtual tools for remote working such as videoconferencing, dissemination of shared documents, etc. In these circumstances, as in a martial law environment, it is important to counter stress and maintain the emotional wellbeing of project implementers as well as project participants, and their psychological support, which can affect productivity. It is also important to provide flexible work schedules to avoid overload. Regardless of the circumstances, it is important to consider the human factor, consider the individual needs and capabilities of the participants, and actively implement tools and approaches to support effective teamwork. Team formation in both cases for managing a working group of participants in competent projects of a higher education institution should occur by creating a pool of potential performers, who should be separately evaluated and prioritized according to the results of achieving goals and objectives. The described optimization problem (4)–(6) is a general optimization problem and it is obvious that the search for competence project participants has many aspects related to performance monitoring, motivation systems, change management and dismissal of performers from the project in case of unsatisfactory performance, etc. Therefore, such a model can be modified according to the competence needs of the project manager.

A limitation of the study is that the project is currently in its first phase and full incorporation of the conceptual model into the research process will be possible after the students have completed the educational components that the instructors have mastered. Despite this, the results of the project have already had a significant impact on the improvement of the competence system in HEIs of the Republic of Kazakhstan. In the future the project will be evaluated and, in case of successful pilot implementation, will be extended to other higher education institutions of the Republic of Kazakhstan and higher education institutions of the project partner universities from other countries.

5 Conclusion

The study constructed a multiple enterprise project life cycle model, which defines the various stages and stages of project development from inception to completion. It also described the project transition pattern between life cycle stages and project competence improvement. Various cases of competence project transformation are considered. The overall structure of a competence project is formally described, which includes the components or tasks of the project and the learning outcomes or outputs of the project. A conceptual diagram of the relationships between the components, outcomes and participants of a competence project is also described. The feature that distinguishes this organizational structure from the known ones is the emphasis on the educational project, the purpose of which is to educate students or students with the possibility of evaluating the quality of work of teachers who are participants in the competence project as a training program. In other words, the evaluation is based on the results of improving the competence level of teachers and training their academic groups of higher education students.

The model of forming a working group of competence project participants is built, which takes into account the specifics of implementation and structure of projects that are carried out for educational purposes in universities, as well as the fact that the performer can simultaneously apply for several projects, etc. The concept of managing the composition of competence project participants is described, which considers the conditions of turbulence in the external environment due to pandemic, martial law, etc. This concept provides for the formation of the so-called human resources reserve, which is formed based on the results of research work and training of teaching staff in other disciplines. This reserve opens opportunities to involve participants of the educational project or teachers at critical moments of time.

According to the results of the analysis and the results of pilot implementation of the first stage of the competences project at Astana IT University it was found that training of teachers allows to significantly increase the level of their methodological competence. This indicates the significant effectiveness of the described conceptual model of human resource management for the development of competences in higher education institutions, as well as their importance for the professional growth of teachers. Improving the methodological competence of employees of higher education institutions is an important factor in improving the quality of education. Since the teachers trained by the competence project will use their experience and knowledge in teaching academic groups of higher education students as the next stage.

An important aspect for the development of this research is the use of evaluation results of university lecturers' methodological competencies to establish inter-university scientific and educational communities. This implies that lecturers from different universities can be involved in teaching disciplines relevant to their expertise, as well as participating in corresponding scientific and educational projects. This is particularly relevant in the context of implementing distance learning systems in universities, where the physical presence of a lecturer on campus is not a necessity. Furthermore, the results of evaluating the level

of methodological competencies can serve as a basis for the effective implementation of academic exchange systems between partner universities. In this way, the connection between universities will be strengthened, and collaboration will expand, forming the foundation for sustainable inter-university educational and scientific communities.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Committee on Research Ethics, Astana IT University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AM: Conceptualization, Data curation, Supervision, Writing – review & editing. AB: Conceptualization, Project administration, Writing – review & editing. OK: Formal analysis, Methodology, Writing – original draft. YA: Data curation, Formal analysis, Methodology, Writing – review & editing. KK: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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