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ASSESSMENT OF PROFESSIONAL COMPETENCIES OF MENTORS IN THE ENGINEERING PROFILE OF SCHOOLCHILDREN

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Abstract

In conditions of the introduction of the national system for assessing its quality, the implementation of new requirements for the quality of training of school and university graduates, the emphasis on advanced training is becoming the most important feature of modern professional teacher education. This article reveals the necessity of training a mentor of engineering and technological profile for preparing pupils. The existing scientific, theoretical and practical achievements and innovations in local and foreign practice in the field of mentor training are listed. The system-oriented analysis of pedagogical research, program and legal documents in the field of engineering and technology education has made it possible to determine the composition of professional competencies, considered as the requirements for the results of training mentors. It determines the success of the teacher as a mentor in the implementation of modern educational standards, initiatives and strategies at the level of general profile, additional and higher education. The assessment of professional competencies of future teachers-mentors for pupils' engineering and technological training in conditions of basic and additional education are highlighted. The author's approach to the mechanism of their assessment is proposed, it includes diagnostic tools. In order to assess professional competencies of the teacher-mentor, cases including interconnected practice-oriented tasks of a meta-subject nature, have been selected and described as the necessary means. The implementation of the author's approach to assessment of professional competencies will contribute to improving the quality of engineering and technological training in line with general and additional education of pupils.

Keywords: Profile education, professional competencies, teacher-mentor, assessment of competencies, engineering and technological education.

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1. Introduction

The strategy of scientific and technological development of the Russian Federation (Strategiya, 2016) is aimed at creating conditions ensuring the leadership of Russian companies in new high-tech markets. These companies will determine the main vectors of development of the global economy in the next 20 years. It is impossible to achieve these goals without increasing the competitiveness of Russian education, which is also ensured due to new models of teacher training for specialized engineering and technological education of schoolchildren. Russia has rich experience and traditions of local higher engineering education built in the Soviet era. However, the implementation of specialized training for pupils who are motivated to receive professional engineering and technological education in the future is unsystematic in nature, and lack of teaching staff and other conditions are obvious. This actualizes the search for didactically substantiated training opportunities for the teacher-mentor to accompany the research and development activities of a student with a strong motivation to receive engineering education in organizations of general and additional education.

2. Problem Statement

Providing the country's competitiveness requires advanced training of pupils, including the engineering and technological profile of training in terms of both basic and additional education. Achieving this raises a number of problems of both scientific-theoretical and practical nature. We will mention the most paramount of them.

2.1. Unilateral Understanding of the Requirements for the Professional Functions of Teachers for Specialized Engineering and Technological Training of Pupils

As a rule, the emphasis is made on ensuring the quality of subject preparation of students for admission to an engineering university. However, this is not enough. Along with the traditional functions of a teacher, the new ones also appear due to modern sociocultural conditions. One of them consists in creating the conditions by means of pedagogical reality for the manifestation of independence, creativity, and a student’s responsibility in the educational space. In this regard, it is a mistake to ignore the function of mentoring in the general meaning while speaking about a teacher in the context of engineering and technological training for pupils.

2.2. Lack of System Local Experience in Training Teachers-mentors for Students in the Programs of Specialized Engineering Training in Higher Education

This lack is connected with the fact that the attention to the content of specialized engineering and technological education in schools in Russia had not been serious enough for a long time. As a result, the training of mentor teachers was insufficient, too. It is necessary to point out that the preparation of bachelors in the pedagogical direction of various profiles is highly specialized in thematic perspective nowadays. As a result, it can be claimed that there is a lack of scientifically based and approved technologies for the professional training of teachers, meeting the new educational challenges. Universities, as a rule, solve this issue on the basis of the needs of the employer, a particular customer, needs of the region for personnel

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through internal resources. For example, in KSPU named after V.P. Astafiev a new model for the training of mentor teachers is being implemented on a trial basis. Students can choose an alternative way of doing a pedagogical internship or master a program of additional education at the same time as getting a vocational education and training. These steps can only partially eliminate this gap in the training of future teachers-mentors.

3. Research Questions

In the course of the investigation the following questions were subject to study:

- What is the successful foreign experience in training mentors?
- What are the local models for the training of mentor teachers?
- What are the requirements for the results of training mentors?
- Are there any tools for evaluating the results of the training of teachers-mentors? What are they?

4. Purpose of the Study

The purpose is to describe the mechanism for assessing the maturity of professional competencies of teachers-mentors of engineering and technological profile for the preparation of pupils.

5. Research Methods

With the view to study the problem of training teachers-mentors, theoretical methods (study and generalization of innovative local and foreign pedagogical experience, regulatory and program documents in the field of professional and engineering-technological training of students in schools; analysis, synthesis, systematization, clustering, comparison, modeling and design) and empirical research methods (observation, questionnaire) have been used.

First of all, the analysis of the existing world experience described in scientific research has been carried out. The sources have been analyzed and, as a result, the best foreign and local practices for teachers providing support to specialized engineering and technological training of students have been identified. Then, retrospective and comparative analyzes have been carried out in order to compare, identify advantages, risks and implementation mechanisms in educational practice.

Abroad the problem of teacher training for supporting project and development activities of schoolchildren is reflected in the research topic of pedagogical content knowledge (Neumann et al., 2019), which opposes both exclusively objective and exclusively didactic paradigms in the training of teachers of the natural-scientific and physical-mathematical profile.

The necessity of developing engineering education starting from school has also been embodied in the implementation of the STEM (Science, Technology, Engineering and Mathematics) model of integrated training for students which is called the “key factor in the possibilities” of personality development that is in demand in various sectors of the economy (Ruhf et al., 2015). In the USA, Canada, Great Britain, Australia, Singapore, Indonesia, and other countries the main emphasis is made on universal access to

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STEM education. It is achieved by including engineering education elements in the curriculum implemented in schools. At the same time, the “out-of school” STEM education movement exists and is gaining momentum (the implementation of additional education programs). These programs make it possible to attract specialists and experts who cannot teach at school due to a number of reasons (The STEM Education Coalition). However, the most important issue in ensuring the effective implementation of STEM education programs abroad is personnel training and special attention in the strategic documents of the leading countries of STEM education (USA, Canada, Australia and Singapore) is paid to it. On the one hand, it is proposed to involve school teachers in the implementation of continuing education programs through the certification system. On the other hand, special training programs for teachers, various trainings and courses are being developed with the goal of constantly updating the theoretical and procedural framework of teachers with the involvement of business. Specialists from the real sector of the economy and university students are involved as volunteers in the events in terms of the implementation of STEM education programs. In foreign countries the creation of communities that coordinate in the field of pedagogical practices of non-formal additional education is widely spread. In the USA there is a National STEM Clubs Programme which interacts with schools and is a resource center for science and technology clubs. Another non-profit organization, the National Association for the Education of Young Children, is engaged in the private accreditation of educational programs (Kukreti & Broering, 2019). Peculiar features of mentors’ training in specialized engineering education are reflected in the research and practice of the international community in engineering pedagogy of the CDIO (Conceive, Design, Implement, Operate) international initiative aimed at special organization of the educational process for the training of an engineer capable of carrying out a full technological cycle (Crawley et al., 2014). Solving the problems of engineering and technological training of students of a comprehensive school at the present stage is impossible without an appropriate teacher training. Local scientists and experts are actively searching for the implementation of such training in the system of teacher education, professional retraining and advanced training.

Methods of training and education in specialized engineering and technology classes in local education are considered in the context of the implementation of the National Technological Initiative (STI). Thus, Merzlyakova and Miroshnichenko (2018) propose to teach schoolchildren new technologies in terms of the STI by building individual educational paths with in-depth study of individual subjects (physics, mathematics, computer science, etc.). It is also necessary for pupils to participate in circles in this area and profile Olympiads.

One of the possible ways of implementing engineering and technological education for schoolchildren in our country is the network interaction of general educational organizations with universities and organizations of secondary vocational education, business representatives (Abushkin, 2017; Graskin & Graskina, 2017). In the works of N.V. Gafurova, V.I. Lyakh, S.I. Osipova, A.N. Solovieva, I.P. Chernova etc. effective approaches and technologies for implementing specialized engineering training of students in the context of integration of educational resources and social partnership of universities, manufacturing companies and secondary schools are proposed (as cited in Chernova et al., 2012; Soloviev, 2017).

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Such interaction allows to test various models of mentoring in terms of engineering and technological training of students together with forming their positive motivation to choose engineering professions, developing their innovative culture, studying modern engineering technology and technological entrepreneurship.

Currently in the process of this interaction STEM centers, laboratories, and clusters are being created on the basis of some leading universities of the country, not only metropolitan but also regional ones. In these centers design and research activities of students under the guidance of school teachers, university teachers, graduate students and undergraduates are successfully implemented. The establishment of pedagogical STEM parks has also begun (the Moscow State Pedagogical University demonstrates the successful experience of functioning of such a center). Their main task is to train teachers-mentors for engineering and technological education of pupils, to develop scientifically based methodological support for general and additional education (Grigoriev et al., 2016).

Such centers are designed to provide professional retraining not only for teachers, but also for specialists who do not have pedagogical education. The practicability of providing the opportunity to develop pedagogical competencies to people without basic pedagogical education in the context of the training of teachers-mentors is justified in the works of Varkovetskaya and Sopin (2013).

For training, retraining and advanced training of teaching staff, it is also necessary to update the educational programs of undergraduate, graduate and further vocational education in pedagogical areas. Thus, Kalekin (2014) studies the methodology of engineering pedagogy of the school as a doctrine of the most general laws, principles, methods of life and professional getting knowledge by a future engineering bachelor of technology in engineering for their subsequent implementation in school when preparing students for sound professional self-determination in the field of modern material production by choosing a profile in high school.

In order to develop engineering and technological education for pupils in our country, the so-called children's technology parks began to be created with the support of the state several years ago. They allow to create the educational environment that “integrates the capabilities of scientific, technical and industrial-technological environments” (Grigoriev, 2016, p. 19).

Today in Russia there are children's technology parks created according to the Quantorium model developed and supported by the Agency for Strategic Initiatives (ASI) as part of the initiative “A New Model of the System of Additional Education for Children”. The institute of tutoring is in demand in technology parks. It allows to develop the necessary “hard-competencies” in the field of pedagogical support of engineering and technological training for pupils among students - future teachers who have the opportunity to undergo practical training on the basis of technology parks.

Mishina and Konyushenko (2017) explain the possibility of training teachers to work in technology parks through the implementation of continuing education programs based on Quantoriums.

However, despite the existing researches, there is no systematic study of the problem of training teachers (educators, tutors) for the system of specialized engineering and technological education of children.

Further the study turned in the direction of the analysis of regulatory documents in the field of education (foreign and local school-specific, higher pedagogical and engineering ones - total about 150 sources of educational standards, requirements for the results of training). This made it possible to identify the requirements for the results of the training of teachers-mentors. In order to highlight the general requirements for the results of the training of mentors during the analytical work, the clustering process was applied, when more private and narrow characteristics were combined into more generalized competencies. This allowed us to identify the professional competencies of future teachers-mentors.

For the further construction of the adequate assessment technologies and the development of diagnostic tools, it is necessary to clearly understand the essence of the measured object. On the basis of the theoretical analysis of psychological, pedagogical, scientific and methodological literature on the structure and content of the concept of "professional competencies of a teacher-mentor," the structurally meaningful model has been identified and described. It has been found that they are an instrument of professional activity. Therefore, any activity of a teacher-mentor requires the manifestation of appropriate professional competencies. This means that when assessing professional competencies it is necessary to use tasks and situations that include the goal of the activity, model and stimulate the manifestation of relevant abilities, personal characteristics. The analysis of theoretical sources and existing experience has shown the lack of such tasks. On account of this, the activity-based approach has made it possible to justify the practicability of creating and using a special system of situations that require the solution of professionally significant problems as a means of diagnosing professional competencies.

The development of appropriate tools from the point of identification and its potential for assessment has led us to the need to take into account its practice-oriented and meta-subject content.

6. Findings

Retrospective and comparative analyzes of normative documents in the field of training teachers of additional and general (basic) education carrying out training and mentoring of students of engineering and technology profile, Federal State Educational Standards of higher education in engineering training program and specialties of training, comparison and clustering made it possible to identify the requirements for professional training of teachers-mentors and fix them in the form of educational outcomes. Thus, five professional competencies have been highlighted:

- PC-1. Able to implement educational programs in accordance with the requirements of federal state educational standards;
- PC-2. Able to carry out the design of scientific and methodological and educational materials;
- PC-3. Able to organize student research activities;
- PK-4. Able to develop a program for monitoring the educational results of students of specialized engineering and technical classes (routes);
- PC-5. Ready for organizational and methodological support of students' teams to participate in Olympiads and contests of engineering and technology focus.

The first three competencies identified by the authors allow a graduate, on the one hand, to carry out the main types of professional activities of a teacher (pedagogical, project, research) in accordance with the Federal State Educational Standard of Higher Education in the field of Teacher Education; on the other

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hand, it allows to implement the basic labor functions fixed in the professional standards "Teacher (pedagogical activity in the field of preschool, primary general, basic general, secondary general education) (educator, teacher)" and "Teacher of additional education for children and adults". The next two competencies reflect the specific character of the engineering and technological profile of the training of teachers-mentors.

All competencies as educational results are described using the terms "capable" and "ready" in accordance with the requirements of the Federal State Educational Standards of Higher Education, as well as the terminology accepted in international documents establishing the requirements of employers for personal, interpersonal competencies and professional skills of specialists, as well as training results of masters of the best international practices of a technical and professional level of work performance (UNESCO, CDIO, WSSS, etc.). At the same time, this allows to determine these competencies through the categories of "knows", "knows" and "owns" further. It is necessary in order to select or create tools for describing assessment mechanisms.

The mechanism for assessing the level of forming of professional competencies of a teacher-mentor is the implementation of current, interim and end-of-course assessment. Current and interim assessments are carried out in order to estimate the dynamics of the level of development of students' professional competencies in terms of acquisition of the educational program. The order of their realization is regulated by internal regulations of the university in priority to a practice-oriented form. A comprehensive final exam is used as a procedure for State Final Certification. A comprehensive final exam (hereinafter referred as the exam) is an exam that allows a student to demonstrate their mastered professional competencies in conditions simulating future professional activities of a mentor.

Consequently, the exam allows demonstrating theoretical knowledge and practical skills and abilities in conditions most closely resembling the realities of a practicing teacher-mentor.

The technology for developing a set of assessment documentation includes: developing tasks and criteria for their assessment, determining the conditions for their implementation and methods of their assessment.

Examination assignments must meet the following requirements:

1) to allow a graduate to demonstrate all their professional competencies and identify the level of their mastery;

2) to be formulated as a practical case consisting of a series of interrelated tasks (3-5 tasks);

3) to take into account the requirements for the results of mastering the program;

4) to have a standardized presentation form for all graduates.

The conditions for completing the tasks fix: time and place of accomplishment, necessary equipment, assessment time.

Task 1. The solution of the competitive problem of engineering and technology for students. The assignment should include a competitive task (for example, a problem of an Olympiad character) of an engineering and technological orientation for a student.

Goal: to demonstrate the ability to solve and design competitive tasks of an engineering-technological orientation, including the tasks of the STI Olympiad (PC-1).

The total time to complete the task is 60 minutes.

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Necessary: to solve the problem; to draw up a decision in a written form on a separate sheet of paper.

The mark for the task is given on the day of its accomplishment after receiving the solution from a participant.

Task 2. Model training session. It includes tasks aimed at the development of a model training project for the implementation of specialized engineering and technological training for pupils and demonstration of its fragment.

Goal: to demonstrate the ability to design and implement a training lesson for students using modern educational and information and communication technologies (PC-1, PC-2, PC-4).

The age range of students on which the lesson is oriented is 8-11th grades. The age of students and the topic of the lesson are fixed by the conditions described in the case.

Total time to complete the task: 150 minutes: 120 minutes for preparation and 20-30 minutes for demonstration of the fragment.

It is necessary: to develop a scenario for a model learning session in accordance with the proposed topic, planned results and the age of students (class); the scenario should include the following elements: topic, goal, tasks, stages, content of a teacher's activities, content of students' activities, expected results, monitoring and evaluation methods, ICTs and other didactic tools used; to write a script. A graduate is prohibited from providing personal data (full name and other information disclosing them as the author of the work); to prepare the materials and equipment needed to demonstrate a fragment of the scenario of the learning session.

To prepare the scenario, it is allowed to use the Internet (except for cloud storage resources), as well as: laptop, multifunctional devices, and office supplies (provided).

The mark for task 2 is given on the day of its accomplishment, after the participants of the project present a model training session. Task 2 should be performed in the presence of the examination committee; its progress should be available for review.

Task 3. Educational and project activities. This should include assignments for preparing a project for organizing and conducting extracurricular classes (circle, elective and similar forms of classes), focused on preparing students for various engineering and technology contests (specialized Olympiads, hackathons, conferences and other professional competitions) and demonstrating its fragment .

Goal: to demonstrate the skills of preparation and arrangement of extracurricular classes in a form of educational and project activities (assessed professional competencies: PC-2, PC-3, PC-5).

A training and project lesson can be presented by a permanent or temporary form of extracurricular activities. The age range of students on which the lesson is oriented is 8-11th grades.

The total time given for completing the task is 145 minutes: 125 minutes for preparation (design): 20 minutes for the presentation of a lesson fragment.

It is necessary: to design and describe the project activities of students (goal, objectives, structure and course of activity) based on the experiment; to carry out the selection of the educational content of the project, based on the experiment, including practical tasks; to draw up a scenario of project activities. Graduates are prohibited from providing personal data (full name and other information disclosing them as authors of the work); to prepare the materials and equipment necessary for the project activity.

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To prepare the scenario, it is allowed to use the Internet (except for cloud storage resources), as well as: laptop, multifunctional devices, and office supplies (provided).

The module is rated on the day of its accomplishment, after demonstrating a fragment of the lesson.

Task 3 should be carried out in the presence of the committee of experts; the progress of its implementation should be available for viewing. To demonstrate the fragment, the organizers invite volunteers (4 people) - students of specialized classes of engineering and technology orientation of Krasnoyarsk educational institutions.

The technology for assessing exam assignments is based on the assessment scheme used at Worldskills championships in pedagogical competencies. To evaluate the exam tasks, an assessment scheme, assessment criteria, assessment forms are developed and the entry list of the expert committee is determined.

Each case assignment is given a percentage of relative importance. The sum of all percentages of relative importance is 100. Thus, each task of the case has a weighting factor: task 1 - 25%, task 2 - 30% and task 3 - 45%.

Exam assignments are evaluated by a 100-point scale in accordance with the criteria. As we have mentioned earlier, substantial characteristics of professional competencies are used as criteria. They are also indicated in valuation sheets. Assessment positions are unified for each task and as they are selected: general cultural development; general professional development; interaction with participants in educational and project activities; methodological support; self-development and self-education.

An examination committee is formed to evaluate the results of exam cases. Representatives of employers (directors of educational institutions, methodologists of additional education organizations), as well as leading experts of technology parks are involved as members of the examination committee. Task 1 of the case is assessed by all members of the expert committee according to unified criteria. Evaluation is carried out according to a 3-point scale and the following principles of scoring are applied: 0 - the criterion was not manifested (task is not completed, missing, etc.); 1 - the criterion was not manifested rather than manifested (accomplishment is below the standard, average level); 2 - the criterion is more likely to be manifested than not (accomplishment at an average level); 3 - the criterion is fully manifested (accomplishment is brilliant) (Table 01).

Table 01. Criteria for assessing task 1 "Solution of a competitive engineering task"

Assessment Positions	Criteria
General cultural development	Demonstrates literacy of records (correct use of terms, statements, correct presentation of reasoning, conclusions, completeness)
	Presents the solution of the problem, arguing and scientifically substantiating own conclusions (including using the means of interpretation and visualization of the information)
General professional development	Demonstrates the knowledge of methods and ways of solving engineering and technology problems
	Demonstrates the completeness of the solution.
	Demonstrates the right decision.
	Deals with scientific methods of cognition

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Interaction with participants of educational and project activities	-
Methodological support	Demonstrates the skills of using solution visualization tools and its results with the help of various tools
Self-development and self-education	Uses data from additional sources
	Demonstrates knowledge and command of non-standard solution methods or presents their own solution method based on a combination of well-known ones

To assess tasks 2 and 3, the committee of experts is divided into two teams assessing the scenario (team A) and the demonstration of a fragment (team B) respectively.

When assessing the demonstration of a fragment of a lesson, each expert uses a 3-point scale similarly to task 1. When assessing the scenario, an expert accrues points from 0 (the criterion did not appear) or 1 (appeared). Tables 02 and 03 provide the criteria of assessment. Cells containing the “-” sign indicate that the aspect is not evaluated by this team.

Table 02. Criteria for assessing task 2 "Model training session"

Assessment Positions	Criteria	Team A	Team B
General cultural development	Demonstrates speech literacy (oral and written)	-	
	Demonstrates workspace planning during a learning session.	-	
	Applies expressive means of transmitting information	-	
General professional development	The project of the lesson has a structure: topic, goal, forms and methods of training, planned results, teaching techniques, lesson plan indicating the time of each stage, class progress		-
	Correspondence of the purpose, forms, means and methods of training to the content of the educational activity and the topic of the lesson		-
	Variability of tasks		-
	The algorithm of a teacher’s actions is presented.		-
	The content of the students’ work at each stage of the lesson is presented.		-
	The availability of methods for assessing the students’ results		-
	The presence of a diagnostic tool and assessment of learning outcomes at individual stages of a learning session		-
	Demonstrates mastery of modern teaching technologies.	-	
	Various forms and methods of control are planned at various stages of the learning session (mutual control and mutual assessment of students, self-control, etc.)		-
Interaction with participants of	Uses various means of communication with participants (oral/written, using ICT, etc.)	-	

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educational and project activities	Demonstrates compliance with norms and rules of communication	-	
Methodological support	Demonstrates the skills of preparing and using didactic teaching techniques at a lesson, including using ICT	-	
	Demonstrates the skills of choosing training technologies and assessment of the results that are adequate to the goals of the lesson		-
	Demonstrates the ability to choose forms of learning		-
Self-development and self-education	Uses data from additional scientific and methodological sources		-
	Demonstrates the use of one's own experience (for example, references to published works, to the results of one's own educational, pedagogical practice, etc.)		-

Table 03. Criteria for assessing task 3 " Educational and project activities"

Assessment Positions	Criteria	Team A	Team B
General cultural development	Demonstrates speech literacy	-	
	Demonstrates workspace planning, learning and project activities	-	
	Applies expressive means of transmitting information	-	
General cultural development	Demonstrates speech literacy	-	
	Demonstrates workspace planning, learning and project activities	-	
	Applies expressive means of transmitting information	-	
General professional development	The topic, purpose, forms and methods of training, planned results, training tools, a plan indicating the time of stages, stages and content of learning and project activities are described		-
	Correspondence of the purpose, forms, means and methods of training to the content of the educational activity and the topic of the lesson		-
	Variability of tasks		-
	The algorithm of a teacher's actions is presented.		-
	The content of the students' work at each stage of the lesson is presented.		-
	The design of an experimental study is planned / a description of the model of students' activity is presented		-
	The presence of a diagnostic tool and assessment of learning outcomes at individual stages of a learning session		-
	Demonstrates mastery of modern technologies for teaching and assessing the results of educational and project activities		-
	Variability of learning and project activities is planned		-
Interaction with participants of	Uses various means of communication with participants (oral/written, using ICT, etc.)	-	

educational and project activities	Demonstrates compliance with norms and rules of communication	-	
Methodological support	Demonstrates the skills of preparing and using didactic teaching techniques at a lesson, including using ICT	-	
	The tasks for search, processing and analysis of the information are planned		-
	Demonstrates the skills of choosing training technologies and assessment of the results that are adequate to the goals of the lesson	-	
	Demonstrates the ability to choose and use forms of organization of learning and project activities	-	
	Scenario reproducibility		-
Self-development and self-education	Uses data from additional scientific and methodological sources		-
	Demonstrates the use of one's own experience (for example, references to published works, to the results of one's own educational, pedagogical practice, etc.)	-	

A graduate with 60 or more points is considered to have passed the exam. The mark “excellent” is given in the case of getting 90-100 points, the mark “good” - 70-80 points, “satisfactory” - 60-70 points.

7. Conclusion

In the presented article the idea of expanding and realizing the potential of the educational space of the university with the aim of preparing sought-after teachers and developing their qualities for mentoring schoolchildren of an engineering and technological profile, as well as diagnosing the level of their formation, is implemented and a tool for their assessment is proposed. Training of mentors in Russia is impossible without an appropriate normative framework, actualization of training programs at the undergraduate and graduate levels. One of the ways of training such teachers is to create network interaction among educational institutions and business organizations.

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