



Innovative learning methods in technical universities: the possibility of forming interdisciplinary competencies

Métodos de aprendizaje innovadores en universidades técnicas: la posibilidad de formar competencias interdisciplinarias

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ABSTRACT:

The article aims to identify the compliance of learning methods used in technical universities, in the Saint Petersburg Mining University in particular. The main results of the research are the survey method, the classification of innovative learning methods, methodical proposals for the organization and application of case methods. This allowed the authors to identify the degree of compliance of the applied learning methods with the required competencies.
Keywords: Interdisciplinary competencies, innovative learning methods, competency-based approach, educational technologies, survey, classification, case methods.

RESUMEN:

El artículo tiene como objetivo identificar el cumplimiento de los métodos de aprendizaje utilizados en las universidades técnicas, en particular en la Universidad de Minería de San Petersburgo. Los principales resultados de la investigación son el método de encuesta, la clasificación de métodos de aprendizaje innovadores, propuestas metódicas para la organización y aplicación de métodos de casos. Esto permitió a los autores identificar el grado de cumplimiento de los métodos de aprendizaje aplicados con las competencias requeridas.
Palabras clave: competencias interdisciplinarias, métodos de aprendizaje innovadores, enfoque basado en competencias, tecnologías educativas, encuestas, clasificación, métodos de casos.

1. Introduction

Various challenges impact the development of the modern educational environment. Among them, one can name the development of the knowledge-based economy and the formation of the market of intellectual labor.

While offering new possibilities, the internationalization of higher education contributes not only to making education more affordable but also to improve its quality since knowledge has become universal, international quality standards have appeared and innovative methods have been introduced.

The formation of international teams and multi-cultural environment in transnational companies cause the need to adapt a university graduate to changing conditions, ensure their readiness for changes in the area of activity and competitiveness in the international labor market.

These requirements lead to the development and active introduction into the learning process of innovation, or interactive, learning methods, which are based on the application of modern scientific achievements and information technologies in education that aim to develop students' creativity and independence. These learning methods offer broader possibilities for the improvement of skills and the formation of students' competencies, and for the improvement of the quality of the higher education system as a whole.

2. Literature Review

In modern Russian and foreign educational activities, as the analysis of scientific sources showed (Shapiro et al., 2007; OECD, 2016; Dushkanova, 2015; Maciejowska, 2010; Zinchenko & Leontieva, 2015; Abdina & Sadatova, 2015; Humburg & de Grip, 2012; Nevskaya & Marinina, 2016; Nevskaya & Ponomarenko, 2016), various innovative learning methods are applied with a focus on the formation of professional and interdisciplinary competencies (soft innovation skills) that improve the quality of professional training. Key goals for the introduction of innovative learning methods are to develop students' intellectual, communicative and creative abilities, to form their personal properties and develop various types of thinking (Dushkanova, 2015).

The theoretical basis for the application of innovative learning methods is the change of the directive-based model to the interactive model, which is more productive and student-oriented. The traditional method implies communication between an academic teacher and a student, the academic teacher's constant control over the student's learning. As far as the directive-based model is concerned, the result of learning is formed on the basis of the distribution of knowledge through the rational organization of the learning process, in which an academic teacher plays an active part (Knight, Wit, 1995).

The academic teacher's role should change on the basis of new information technologies and learning methods because he/she turns from a bearer of knowledge into a leader, a person who initiates a student's independent creativity. The interaction between the academic teacher and the student is accompanied by the student's more active work and his/her creative rethinking of obtained information. Main criteria of the interactive learning model are the possibility of an informal discussion, free presentation of materials, the smaller number of lectures vs. the larger number of seminars, a student's initiative, group assignments that require collective efforts, constant control during the semester and the execution of written assignments.

The priority principle of the higher education system is to take into account the interests of a student. In this connection, academic staff in universities need to develop and introduce such learning techniques and methods that would focus on unlocking students' creative potential and their willingness to learn. To achieve the goal of developing students' cognitive activities and creative initiative, the following learning methods are applied: cooperative learning (in small groups), the project method, individual, differentiated, module-based and Internet-oriented learning used in order to improve independence. The main innovative methods include role and business games (game imitation modeling), technologies for collective and group activities, project technologies, problem learning, ICT technologies, case methods and others (Zinchenko & Leontieva, 2015; Abdina & Sadatova, 2015; Dobrynina, 2010; Batrakova, 2010).

Russia has seen possibilities for a gradual shift from the directive-based model to the interactive learning model. For this reason, it is interesting to analyze the foreign experience of the application of innovative learning methods in both EU member states (Finland, Sweden and Estonia) and the United States. The analysis showed that the modern stage of development in education systems in developed economies is driven by the formation of single business space, internationalization of knowledge, development of communication technologies and other socio-economic factors.

We identified the main reasons that determine the application of innovative learning methods:

- exchange of knowledge (competencies) with the businesses community, the establishment of partnership relations with the business community;
- introduction of responsible autonomy in higher education institutions (OECD, 2016) (a combination of independence in education programs and responsibility to the society for results);
- aspiration to provide interdisciplinary research for entrepreneurship.

For instance, of interest is experience amassed by Finland, a leading EU country when it comes to the introduction of innovative methods and technologies in education (Rubvalter & Rudensky, 2007). The country's advantages include political stability, economic transparency, advanced infrastructure, strong scientific cooperation among enterprises, research centers and universities. For the purpose of forming an intellectual society and ensuring competitiveness, Finland elaborated a national strategy that is based on knowledge and competencies (Bratchikova, 2013; Radchenko, 2011), which aims to achieve dynamic absorption of new technologies, the high level of public education, a favorable business climate and leadership positions in the economy of knowledge (Kulikova, 2012). The country's education system provides for the development of broad competencies – unified skills and personal properties that enhance the efficiency of work and collective interaction.

The high level of development and demand for innovation entrepreneurship determines specific features of an education process when training specialists and bachelors. Close ties among universities, research centers and leading Finnish companies are the factor that provides high operating efficiency by the encouragement of young qualified professionals to work at operating concerns, the focus of research on the areas, in which enterprises are keenly interested, the fastest introduction of know-how. On balance, Finnish universities' innovation research is focused on open innovation that suggests the generation of ideas in cooperation between enterprises and clients.

The Finnish Funding Agency for Technology and Innovation (Tekes) is a state expert organization in the area of research and technology development that funds industrial R&D, as well as R&D in universities. Attention is mainly paid to complicated, innovative and risky projects (Finland in Numbers and Facts, 2013). The education system develops as the most important element of an innovation environment. The development of creativity and students' involvement in innovation is one of the educational objectives in Finland, while business ideas grow into specific commercial projects.

For example, Aalto University (Helsinki) has specially equipped premises, the environment, which promotes the constant generation of ideas. The best ideas, through a contest, can materialize in specific projects and know-how.

The main advantage held by the Lappeenranta University of Technology (LUT) is the cooperation with businesses and municipalities. For instance, LUT's Lahti division has long signed up Lahti citizens for urban planning, encouraging clients to implement new ideas in the services sector, and employees to participate in corporate development.

Finnish educational institutions are residents of business parks (technology parks), i.e. centers, in which innovation is developed and brought to the attention of specific consumers (manufacturers).

The most important problems in the modern US education policy is the development of engineering education as provided for by *the Federal STEM* (Science, Technology, Engineering, Mathematics, 2013; Mednikova & Senashenko, 2014). It is carried out in the following areas:

1. Development of efficient learning methods (evidence-based) and the application of innovative learning approaches.
2. Stronger support from federal authorities of efficient partnership among universities.
3. Development of a partnership between higher education institutions and industrial sectors.
4. Improvement of mathematical education both in school and universities.

Moreover, American universities pay much attention to the formation of entrepreneurial skills among students by increasing the number of courses on entrepreneurship (from 250 in 1985 to 5,000 in 2011), hiring academic teachers who have personal entrepreneurial experience and participate in startup projects or university-linked business incubators (Yoder, 2012; Stephens, 2013) In this case, the quality of practice-oriented learning improves substantially.

The most studied and popular method is the case method (*case-study*, the method of specific situations, the method of situational analysis that was first applied in the [Harvard Business School](#) in 1924) that is understood as learning based on the description of real economic, social and business situations, the core of which includes three elements (the situational approach, the empirical base and collective leadership in the making of a managerial decision (Gladkikh, 2005; Surmina, 2002; Strelakova & Beliakov; 2013; The European Case Clearing House, 2016).

3. Methods

Hypothesis: Innovative learning methods are not sufficiently used in the course of training in technical higher education institutions.

Research Question

1. Are there any problems with the application of innovative learning methods in technical universities?
2. What are the possibilities and areas for the adaptation of foreign experience of applying innovative learning methods in Russian higher education institutions?
3. What recommendations should be given in the field of application of innovative learning methods in technical higher education institutions?

A survey was compiled and students of a Russian technical university (the Saint Petersburg Mining University) who major in technology and economics participated in it. After, we assessed the achieved level of application of innovative learning methods and analyzed the application problems.

We compiled a questionnaire consisting of 14 closed-ended questions.

The purpose of the survey is to determine how often innovative learning methods are applied in a technical university among students who major in technical and economic sciences.

The survey was carried out in a technical university that trains specialists for all sectors of Russia's mineral resources complex. Mineral resources provide Russia and developing countries with substantial contributions to GDP, taxes and employment. A diversity of specializations requires the formation of a large number of professional competencies on the basis of advanced laboratory facilities.

The survey is representative as the non-random sample includes respondents from among the Mining University final-year students. To conduct the survey, we used the quota sampling with targeted characteristics (the year of study (bachelor graduates, 4th year of study), areas of training (economists and production engineers), and the place of study (the Mining University)).

The selection of final-year students is driven by the completion of training and the formation of most competencies. The general population is 600 people, the sampling population is divided into two groups (technology and economic students, 120 people, or 20% of the general population).

Our observation when attending foreign universities and interviews with master-degree students in foreign higher education institutions showed possibilities and areas for the adaptation of foreign experience, which was amassed when applying innovative learning methods to Russian technical higher education institutions.

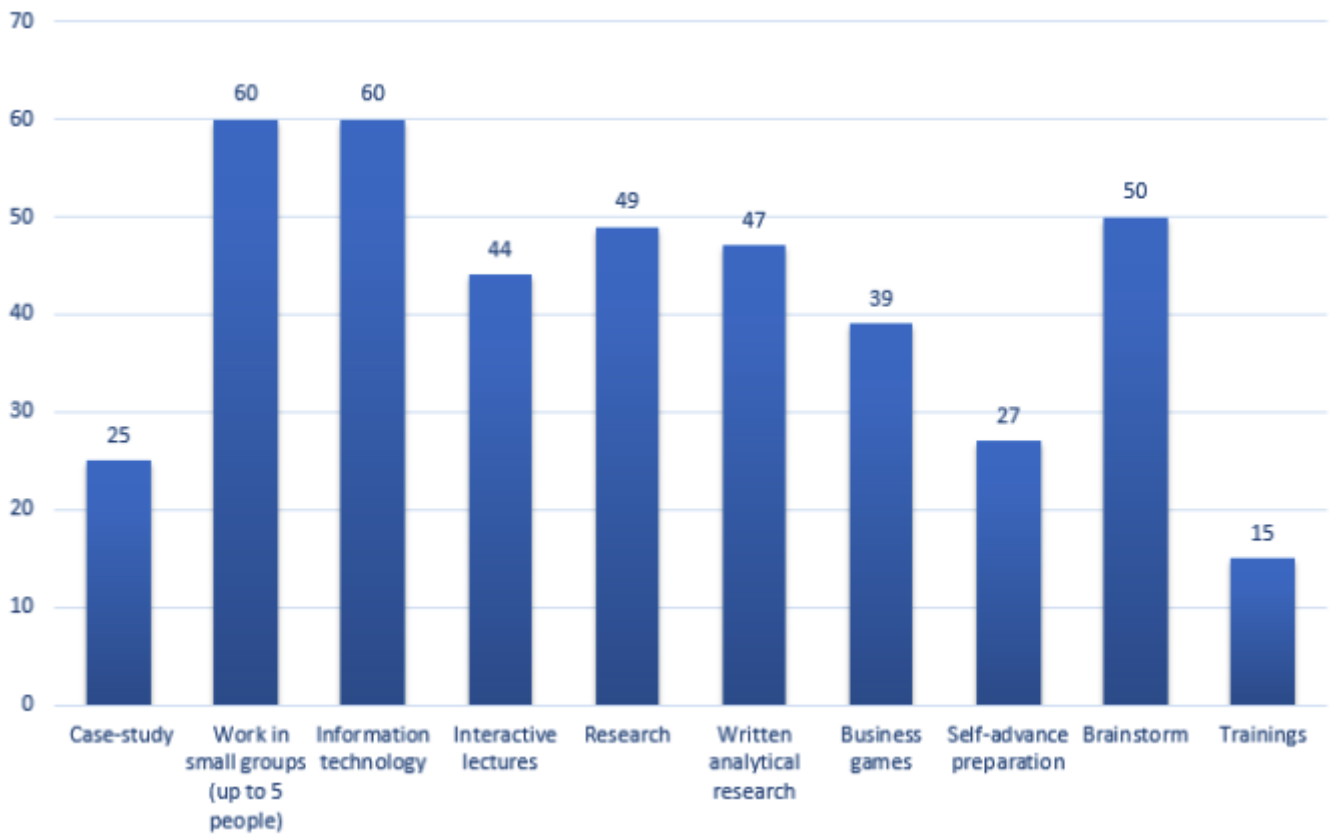
We made recommendations on the application of innovative learning methods when forming interdisciplinary competencies.

4. Results and Discussion

The results of the survey among the technology and economic students in the Mining University showed that the most popular innovation learning method is the method of information technology. The comparison of the survey results shows a big difference in the statistical data on the application of the methods under research in the groups of engineering and economic students. For example, the application is low in terms of case-study (8.3%), business games (6.67%), research (13.3%); there are no brainstorm or training courses for the engineering students and over 65% in the application of business games, work in small groups, interactive lectures and brainstorm for the economic students. This imbalance shows insufficient training of the engineers with regard to the formation of social, managerial and communication skills. This results in an objective gap between the current and required competencies (Figures 1, 2, Table 1).

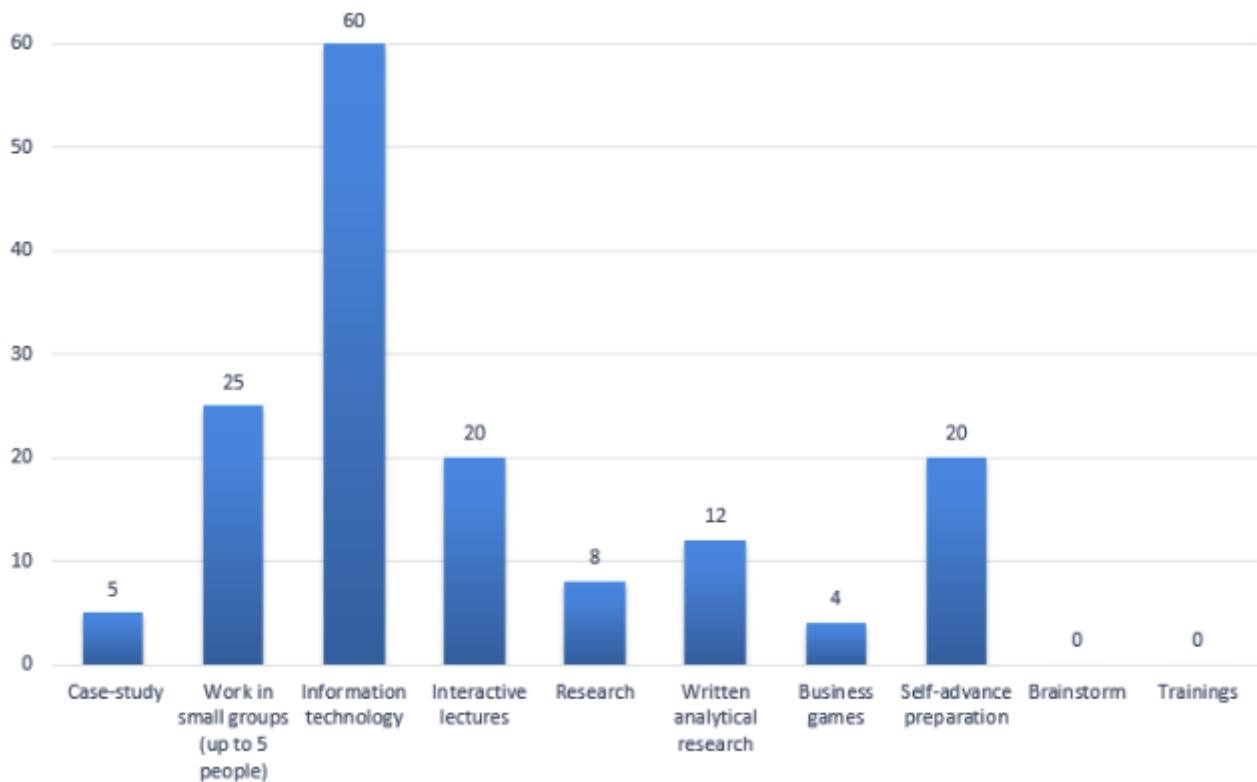
Figure 1

Survey results for the economic students on the application of innovative learning methods in the Mining University



Source: compiled by the authors

Figure 2
Survey results for the engineering students on the application of innovative learning methods in the Mining University



Source: compiled by the authors

Table 1
Survey results for the economic

and engineering students

Innovative methods	Engineering Sciences		Economic Sciences	
	Quantity of people	Weight, %	Quantity of people	Weight, %
Case-study	5	8.3	25	41.6
Work in small groups (up to 5 people)	25	41.6	60	100.0
Information technology	60	100	60	100.0
Interactive lectures	20	33.3	44	73.3
Research	8	13.3	49	81.6
Written analytical research	12	20.0	47	78.3
Business games	4	6.67	39	65.0
Self-advance preparation	20	33.3	27	45.0
Brainstorm	0	0.0	50	83.3
Trainings	0	0.0	15	25.0

Source: compiled by the authors

The analysis of the application of innovative methods showed that in humanities studies, educational institutions widely apply the methods of problem description, presentation, case-study, work in groups, brainstorm, critical thinking, quizzes, mini-surveys, business and role games, the Insert method (the method when individual marks are made when writing a 7-10 minute associated essay), fast survey, and the completion of questionnaires. Obtained results confirm data from the sources (Zinchenko & Leontieva, 2015; Abdina & Sadatova, 2015; Dobrynina, 2010, Batrakova, 2010).

We revealed some advantages and disadvantages of the case method after interviewing students who obtained their master's degrees in Russian and foreign higher education institutions. On the one hand, the approach to a situation in the case method allows students to learn how to apply specific scientific methods, etc. Meanwhile, the main problem is the necessity of generating knowledge and its adaptation to various situations. Moreover, cases can be individual and group, and designed for various objectives. A student's potential is revealed wider in individual cases, the way he/she decides to meet objectives (analytical mindset, systematic thinking, etc.), the substantiation of conclusions, the ability to make decisions and to formulate a point of view, etc. As for group cases, teamwork is extremely important as it allows group members to analyze to what extent a student is good in teamwork and result-oriented. Obtained results are similar to those revealed in the articles (Gladkikh, 2005; Surmina, 2002; Strekalova & Beliakov, 2013; The European Case Clearing House, 2016).

The application of case methods to students who study management allows them to acquire practical skills, e.g. HR management and corporate governance, which cannot be acquired in the course of traditional studies and even during an internship.

As analysis showed, most Russian higher education institutions are marked by a low degree of internationalization of education. For this reason, a special role in the application of the case method and other innovative methods promotes the formation and development of communication skills that meet the requirements of a modern multicultural environment.

We developed proposals on the solution of organizational methodical problems when applying the case method:

1. The academic teacher should fully control the study of discipline, i.e. to deliver lectures and to conduct practical classes.
2. Problems related to the verification of obtained results can be solved when representatives of a company participate in the development and the discussion of case results, which adds more energy to the work because this immediately gives a qualified assessment of results obtained in the course of the solution.
3. Cases make it possible to raise students' responsibility because deadlines should be met.
4. In the course of studies for a bachelor's degree, the case method should be applied given competition among groups of students in the form of mini cases, transforming them into business situations and business games. Since a bachelor's degree is the first level of higher education, the decision on a profession is not always final. As a result, the case method can encourage students' interest and motivation.
5. The application of the case method plays a special role when training holders of a master's degree. As masters are more motivated in specific learning programs, have some production experience (e.g. gained in the course of internship), better understand their future profession, it makes sense to apply cases that are average in terms of the format.
6. When using full-format cases (30-50 pages), it is necessary to provide 8+ hours for the solution of a problem and time for the independent search of information.
7. For the integrated study of disciplines and understanding of interdisciplinary relations, it is possible to apply integrated cases, in which various management problems are considered. Such cases can be applied in the course of internship and in virtual companies.
8. The use of case methods, in which employers participate, is effective. For instance, EuroChem arranges and conducts annually case tournaments in the Mining University, in which the mining holding's executives participate. Engineering cases are developed on real production conditions of a specific company for the championship. The solution of a case helps students form interdisciplinary competencies, soft skills, get familiar with the company's corporate culture and values, and become emotionally involved through communication with senior executives.

Technical universities pay much attention to the development of technical education by forming high-tech material and information infrastructure for studies. Scientific laboratories improve the efficiency of educational technologies by getting students involved in real research and operating activities, and by helping them acquire professional competencies that are in demand in the conditions of real production, knowledge of goods and services. In the course of studies, students use academic equipment, devices, laboratory stands, simulators, training devices, sections of components, training sets and visual aids.

Academic equipment and practical aids make it possible to reproduce vividly and efficiently basic types of standard technological processes related to the preparation and extraction of mineral resources. Models were developed and are applied to imitate basic emergency and working situations throughout the operating cycle of a mine ranging from prospecting, exploration and production, and specialty software products for the mineral resources sector (Shabarov, et al., 2000b, Overchenko, et al., 2017; Isheysky, et al., 2018).

When applying innovative methods in technical universities, the main problem concerns the non-integrated use of the methods and the necessity of developing interdisciplinary competencies. Special methods, the content of which should comply with the field, profile, specialization and educational program, are required for the formation of professional interdisciplinary competencies among university graduates. The choice and the application of innovative learning methods in a specific higher education institution are determined by the following factors:

- specialization of a higher education institution;
- fields, profiles and students' learning programs;
- structure of academic load (classroom studies, independent work, internship);
- structure of subjects learned (proportion of time spent on lectures and practical classes);
- readiness of a university's management to assist the introduction of innovative learning methods;
- whether a higher education institution has resources for the introduction of innovation (laboratories, training bases, computer classes, material and technical support);
- qualification of academic staff and their readiness to apply innovative methods (if academic teachers have required competencies and master innovation techniques);
- level of cooperation between enterprises and a higher education institution (degree of a higher education institution's focus in the training of specialists on future employers, exchange of competencies);

- higher education institution's possibilities (aspiration) to internationalize training.

Research related to the analysis of competencies held by engineering professionals by comparing Russian and EU experience allows us to conclude that for efficient engineering careers in the modern conditions most university graduates do not have sufficient competencies obtained in the course of studies (Shabarov, et al., 2000a). University graduates acquire new competencies by seeking additional education, especially in the area of management, business administration and foreign languages, i.e. a sign that their personalities were not sufficiently mature when they obtained higher education (Shmatko, 2012).

There are substantial differences between characteristics of Russian and foreign engineers with regard to the organization and coordination of teamwork, efficient time management, the ability to critically assess their own and someone's ideas, the use of computer programs and the Internet for professional purposes.

Similar observations for Russia and European countries relate to the assessment of the meaning of general essential characteristics such as the ability for the organization and self-organization, sensitivity to new trends and the ability to learn, as well as communication skills. Their role especially increases in a situation when a specialist decides to change a profession or an employer.

Technical skills, as opposed to general or social, are substantially less convertible and transferrable from one occupation to another. Given diverse errors in the training of engineering professionals when not only in Russia, but also in other countries, the demand for competencies structurally differs from supply, social skills become especially valuable (Shmatko, 2012). Labor market trends encourage people to learn new professions and acquire new competencies.

Foreign experience for the application of innovative training methods in Russian higher education institutions can be adapted by expanding cooperation with enterprises, offering entrepreneurship classes and forming multicultural competencies.

5. Conclusion

In the conditions of a constantly changing economic environment, rising needs for intellectual labor, internationalization of education, and a shift to the competency-based model require the development of innovative forms and methods of training, which make it possible to form both professional and interdisciplinary competencies.

The classification of innovation competency-based learning methods is supplemented by the following characteristics: the form of organization of learning methods, the degree of complexity and the type of competencies to be acquired.

The analysis of the survey results showed that the information technology method is used most of all among innovative learning methods and that there are substantial differences in the frequency of application of innovative methods in groups of engineering and economic students. This is a sign that engineers are not sufficiently trained for the formation of social, managerial and communication skills, thereby entailing an objective gap between the available and required competencies.

Russian and foreign experience gained in the course of introduction of innovative learning methods and technologies shows that given general methodical approaches, there are certain differences in the organization of measures aimed to introduce innovation in Russia and abroad where innovative methods are above all a means for the commercialization of knowledge.

The application of innovative methods largely depends on a higher education institution's specialization and financial possibilities, professional training of academic staff, and the institution's readiness to cooperate with the business community. Specific features of applying various innovative methods for universities that have a clear-cut sectorial focus in studies are determined by the distance to internship facilities, the need to be constantly in touch with core enterprises, the application of imitation methods and models. Of special importance are engineering students' interdisciplinary competencies that can be formed when applying engineering cases.

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