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# Specific features of forming interdisciplinary teams and designing projects in petroleum engineering

**Słowa kluczowe:** edukacja zawodowa, inżynier naftowy, przemysł naftowy i gazowniczy, edukacja ustawiczna, przygotowanie fachowe, technologie edukacyjne, rynek pracy, zespoły międzyprzedmiotowe, kompetencje profesjonalne, podejścia innowacyjne
**Key words:** professional education, petroleum engineer, petroleum industry, continuing education, specialist training, educational technologies, labour market, interdisciplinary teams, professional competences, innovative approaches

Economic safety and competitiveness of each state is supported by natural, energy, human, tangible and intangible resources. There is a model signifying the connection between economic competitiveness and volume of GDP per person[1]. The latter is combined with the level of well-being of the population. This link to a large extent depends on the quality of human capital, with such important characteristics as education of the population and its willingness to change in accordance with changing conditions of external and internal environment. Global challenges of the modern world (climate diversity, globalization, demographic situation, competition for resources, technological revolution, etc.) become powerful drivers for growth of new trends in the social, economic, technical and political spheres. One of such trends in science, technology and education is interdisciplinarity, that Berger found as a "principle of organization of scientific knowledge, which opens wide possibilities of interaction of many disciplines in solving complex problems of nature and society"[2].

[1] Wealth of nations, 2012, *The Economist*. Retrieved from: http://www.economist.com/node/21562228.
[2] G. Berger, *Opinions and facts. Interdisciplinary: Problems of teaching and research in universities*, OECD, Paris 1972, p. 34.

The objective of the paper consists in revealing notions like "interdisciplinarity" and "interdisciplinary team" which are correlated with shifts in the organization of university petroleum education and continuing qualified growth. The most important methodological principle to ensure the sufficiency of education system for the petroleum industry has been identified – the education system ought to be sensitive to the diversity in science, technics and technologies, that, undoubtedly, result in advances in petroleum engineer's professional activities. Interdisciplinarity is regarded as one of the adequate mechanisms to hold up a keen interest of young age group for oil and gas engineering; to boost an ambition of future petroleum specialists, to embellish the activity of cooperation between experienced workers from various spheres.

The analysis of a myriad of researches regarding the attributes and competencies a graduate petroleum specialist ought to get has shown the significance of interdisciplinary technique among the key factors that ensure competitiveness of petroleum engineering learners in labour market. The meaning of interdisciplinarity involves a transdisciplinary aspect and Patil takes the view that it is practice to boost the research prospect regarding any occurrence outside the foundation of a specific field of study[3]. It is Chan's belief that the conception of combination and unification of understanding, that is the basis of this principle, and likely to have not only a millennium[4].

Generally, petroleum training depends on the proficiency of physics, maths, geology and chemistry. Petroleum engineering assures that energy will keep being a main part to social operation and person's common activities. Petroleum experts resolve vital issues that donate to energy safety and public welfare. Petroleum specialists frequently operate on worldwide petroleum projects in developing fields in Asia, Africa, South America and Eastern Europe. However, there are certain limitations in engineering evolution from purely technical viewpoints[5]. The essential point of Lori's analysis is that interdisciplinarity ought not to be a crew of people where everybody is a professional on everything; but it is a team of people from various fields of study in the same location; developing the instruments for everything that is required in all areas; forming of information exchange. Lori[6]

[3] A. Patil, *Global accreditation for global engineering attributes: A way forward,* 2008. Retrieved from: http://acquire.cqu.edu.au:8080/vital/access/services/Download/cqu:4206/ATTACHMENT01?open=true.

[4] D. Chan, *A global engineer for the global community*, „Policy Engagement", 2009, nº 1 (2), p. 5.

[5] M. Tarvainen, *Engineering education and interdisciplinary studies,* 2006. Retrieved from: http://www.pantaneto. co.uk/ issue22/tarvainen.htm.

[6] N.F. Lori, *Interdisciplinarity in engineering education: Trends and concepts*, „Engineering Education", 2014, nº 14, p. 33.

draws attention to the role of idea-filtering communication that is valuable, permitting helpful data evolve into institutional information, which is the real well-being of any institution.

The history of science, engineering and technology occasionally shows, as a consequence of interdisciplinarity, evident successes and breakthroughs that appear at the confluence of different disciplines, spheres of activity or sciences. True evidence of this are the newly emerging successful scientific fields such as biophysics, bionics, medical electronics, geoecology, and many others.

Petroleum engineering interdisciplinarity can ensure not only competitiveness of a crew, state's economy in the worldwide labour force division, and contributes to succeed in the global competition in the relevant markets of the world, thus, interdisciplinarity certainly stands for a source of wealth. Simultaneously, it should be stressed on interdisciplinarity in its formal representation, when the result of the joint work of specialists in several research fields will be the sum of the result of their work, as well as when, due to the synergistic effect, the result may be more significant. In other words, a result that can be obtained in this case can never be obtained as a result of the activity of one of the participants in an interdisciplinary crew. Most frequently, this outcome is reached by the way of collective activity and application of methods, principles, tools, means, viewpoints applied by the representatives of various areas of science.

Causing terms for achieving synergistic effect is rather challenging but compulsory task in the organization of interdisciplinary activities. In this case we may expect to achieve fundamentally new scientific results, engineering and industrial products to ensure victory in the competition on the world markets. Precisely such understanding of interdisciplinarity has to be used as the basis to stimulate the work carried out by interdisciplinary crews.

A typical way of local and national funds to stimulate interdisciplinary activity, when interdisciplinarity is interpreted as presence in the societies of various research areas representatives, guides that members form like a formal applied partnership to obtain and receive the financing. It is really quite obvious that such a position leads to inessential shift of funding towards such formal consortiums and underfunding of really promising projects, including monodisciplinary projects[7].

The results of interdisciplinary projects are determined by the level of staff involved in their implementation. Innovative approaches to engineering education include not only the tools and methods to improve the contents of education and

[7] J.Th. Klein, *Interdisciplinarity: History, theory, and practice*, Wayne State Uni. Press, Detroit 1990, p. 19.

learning techniques but also the creation of specific environments at higher education institutions (HEI), ensuring the formation of mindset, in particular in sustainable development and interdisciplinarity.

The process of preparation specialists to work in interdisciplinary projects and teams could and should be managed. In recent decades a lot of research was dedicated to the problems of interdisciplinarity in training. In many researches the theory and practice of interdisciplinarity is discussed in detail, however, there is a small number of works addressing the issue of the training specialists who are able to operate effectively in interdisciplinary crews and influence them[8].

Control of any action signifies precisely outlined aims, purposes, needs describing the function of the members and developing conditions that advance the process and guarantee its use. Direction of practicing specialists ready to operate favourably in interdisciplinary teams and take part in answering integrative issues demands considerations and formulating the basic methods of interdisciplinarity in engineering education, principles and management techniques, suitable for the task.

Talking about petroleum engineering training and leaving aside organization of interdisciplinary engineering projects implementing, we will stress on the features of the training specialists in the area of petroleum engineering to work in interdisciplinary teams. For understanding whether the university environment permits to develop and manage interdisciplinarity it is needed to outline a number of direct and indirect features indicating the presence of such conditions at technical universities. With a certain degree of completeness, the list of features includes the following: interdisciplinary department; participation in national and international interdisciplinary projects; team project placed on training; subsequent CDIO techniques; academic programs that provide training specialists of the future; the system allows to get two degrees in parallel.

It should be noted that availability of infrastructure involves the system of selection and training of the participants of interdisciplinary projects; programmes for scientific and teaching staff professional qualification development in interdisciplinary fields; the system of selection and training managers of interdisciplinary projects; analysis of the domestic and global markets of interdisciplinary projects in science, technology and education.

Group project based learning (PBL) is becoming increasingly common in the HEI environment, as a basis for the development of practical-oriented and prob-

[8] M.S. Moky, *Transdisciplinarity in Higher Education: expert opinions, problems and practical solutions*, „Modern. Problems of science and education", 2014, no 5. Retrieved from: http: //www.science-education.ru/pdf/2014/5/87.pdf.

lem-oriented education. Group PBL is one of the most effective methods to develop competitive skills required by future professionals to work in interdisciplinary projects. CDIO initiatives have combined approximately one hundred universities throughout the world[9]. The main focus in the organization of this work is to create favourable conditions for the formation of the graduates with critical and system (comprehensive) thinking, the development of competencies that enable them to adapt in educed time period to the real professional activity at enterprises. At the same time, the principles of CDIO Initiative ares a good basis for the implementation of interdisciplinary projects and the opportunity to accumulate practical experience of focused teamwork.

Training specialists for the future still remains at the preparatory stage of discussion possible majors both in Ukrainian and foreign engineering universities. In particular, there are some publications showing that main part of majors (educational areas) of training for the future are interdisciplinary[10]. As an illustration, evaluators of consequences; managers of corporate consumption; biowaste optimizers; environmental minimizers; experts in "Internet of things" technologies; dismounting engineers; geoengineers – specialists in weather control; earthquake forecasters; engineers of heavy air; radical innovators (experts in the revitalizing, increasing memory capacity, architects of global systems, robotic earthworms, etc.)

It is expected that highly demanded professionals will be those who acquire new skills, such as the ability to make changes –"transiters"; the ability to overcome a negative reaction to the new technology – "boomerangs"; the ability to extend the life of "dying" technology – "ultimate runners"; the ability to find the critical point of inflection in the system, to determine best time place and information required for introducing the changes – "inflectionists"; the ability to tune elements of the system so as to obtain the best possible result "optimizers"; and others[11].

Higher education degree in more than one field, to a certain extent, becomes the key competitive point for the specialist to be enrolled in interdisciplinary teams and projects. The work to create conditions that allow students to get two degrees in the reduced period of training time, virtually is non-existent in the majority of Ukrainian universities. However, the process is carried out spontaneously, at the

[9] T. Frey, *162 Future Jobs: Preparing for jobs that don't yet exist*, 2014. Retrieved from: http://futuristspeaker.com/2014/03/162-future-jobs-preparing-for-jobs-thatdont-yet-exist.

[10] P. Luksha, *Educational Innovation, or why do we need to change education*, „Sotrudnichestvo", 2015, no 3–4, 3–24. Retrieved from: http://oash.info/ download/news/news- 4153.pdf.

[11] Ibidem.

request of students, who realized that the availability to get different degrees allows to work in not only one profession field, is at least a solid competitive advantage. Taking into account the elements and characteristics of the university infrastructure, which would provide the readiness to manage training of specialists capable to operate in interdisciplinary teams and projects, one should admit the lack of such infrastructure.

In order to develop a system at technical universities, providing training of petroleum specialists able to work in interdisciplinary teams and projects, requires the formulation of the basic principles of interdisciplinary activities, the definition of requirements to the participants of the interdisciplinary teams, formulation of a list of specific competences for these professionals, as well as the choice of methods, tools and relevant learning and teaching tools.

The basic principles of interdisciplinary activities may include: 1) the principle of "flight of ideas"; 2) the principle of filtering ideas; 3) the system approach principle; 4) the principle of social responsibility; 5) the principle of synergy; 6) the principle of advanced development. On top of that, each of these principles should be realized in a holistic way following the determined sequence of actions that allow to develop an algorithm to manage educational process and training of petroleum specialists able to work successfully in interdisciplinary projects.

1. The principle of "flight of ideas" is realized through the development of the university environment (system of centres to generate new ideas) for creativity and innovation, and the creation of conditions for selection and development of creative personalities.

2. The principle of "filtering of ideas" is implemented by the sequential actions with different target groups, allowing to select the most effective and realizable idea for further processing and implementation.

3. The principle of "system" (holistic) approach is performed taking into account the interests of all stakeholders, interaction between the individual elements of the project and their influence on the final outcome of the project.

4. The principle of "social responsibility" involves the compulsory public evaluation of the implications of interdisciplinary project, including the appraisal of public influence of the project outcomes, achieved in definite fields of study.

5. The principle of "synergy" comprises designing expected results that cannot be obtained without the interaction of members in the various spheres of training (it is impossible to receive such outcomes due to the efforts of only one of members of an interdisciplinary plan).

6. The principle of "progressive development" is used according to planning and reaching of unique aims of interdisciplinary plan, that does not have parallels, and allowing to give an opponent position in the international division of labour.

The next list involves naturally required, but probably not full enough elements to manage educational process and training of specialists able to work successfully in interdisciplinary projects and includes: 1) methods and criteria for the selection of the Chief Engineers of Interdisciplinary Projects (generators of ideas, visionaries, inventors, who tend to have unconventional thinking, inspirers, charismatics, innovators, managers, systems analytics); 2) conditions to ensure "flight of ideas", generation and selection of ideas, searching and choosing of participants; 3) integrated educational programmes (training specialists for the future); 4) effective learning and teaching tools; 5) system for selection of advisors of interdisciplinary projects; 6) training and competence development programmes for mentors.

Determination of the state of the problem, conditions, tools, regulations, principles and organization issues to carry out interdisciplinary projects allows to find approaches to the growth of preliminary management system to train future oil and gas specialists competent to work successfully in interdisciplinary projects.

## Conclusion

All things considered, organization of introduction of effective interdisciplinary projects in science, engineering, technology or education requires not only the involvement of specialists from various fields of activity, but also planning a synergistic effect, as a kind of guarantee of obtaining fundamentally new solutions and results that, under certain circumstances, can ensure a victory in competition in the relevant markets. Training of leaders and specialists for such projects who are able to work effectively in interdisciplinary teams and projects – specific and not familiar task for modern engineering universities. Those learning and teaching tools that are used today, contents of educational programs, available infrastructure can hardly ensure the preparation of interdisciplinary projects leaders, professionals able to think freely outside the box, to generate innovative interdisciplinary ideas and projects, efficiently organize interdisciplinary working teams. All activities of university teams in this area should be based on holistic understanding of the challenges they face, the ability to change in the right way the form and contents of engineering education, to create the necessary infrastructure, and crucially, the ability to change themselves. Training petroleum professionals able to work successfully in interdisciplinary teams and projects can and should be managed.

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## Summary

The article investigates the issues of training specialists in the petroleum industry ready to work in interdisciplinary teams and designing projects. Petroleum engineering interdisciplinarity can ensure not only a competitive position of a team, country's economy in the international division of labour, but also helps to win the global competition in the relevant markets of the world, therefore, interdisciplinarity really becomes a source of wealth. At the same time, we must distinguish between interdisciplinarity in its formal representation, when the result of the joint work of specialists in several research fields will be the sum of the result of their work, but also when, due to the synergistic effect, the result may be more significant. In other words, the result that can be obtained in this case can never be obtained as a result of the activity of one of the participants in an interdisciplinary team. Most often, this effect is achieved by means of mutual intersection and application of methods, tools, approaches used by the representatives of different disciplines,

science, trade. So, organization of implementation of effective interdisciplinary projects in science, engineering, technology or education requires not only the involvement of specialists from various fields of activity, but also planning a synergistic effect, as a kind of guarantee of obtaining fundamentally new solutions and results that, under certain circumstances, can ensure a victory in competition in the relevant markets.

## Osobliwości formowania międzyprzedmiotowych zespołów i planowania projektów w inżynierii naftowej i gazowej

### Streszczenie

Artykuł poświęcony jest badaniom zagadnień niezbędnych do przygotowania specjalistów dla przemysłu naftowego i do pracy w międzyprzedmiotowych zespołach oraz planowania projektów. Międzyprzedmiotowość w inżynierii naftowej może gwarantować nie tylko pozycję konkurencyjną w zespołach czy w gospodarce państwa w międzynarodowym podziale pracy, ale może pomóc zwyciężyć w konkurencji globalnej na rynkach świata. Oznacza to, że międzyprzedmiotowość może stać się podstawą dobrobytu. Celem artykułu jest przybliżenie międzyprzedmiotowości i jej znaczenia w przypadku podjęcia badań przez specjalistów z różnych dziedzin. Przez połączenie rezultatów pracy przedstawicieli nauki i gospodarki, w wyniku synergii, można uzyskać przewagę ekonomiczną. Wprowadzanie zatem efektywnych, międzyprzedmiotowych projektów w nauce, inżynierii, technologiach czy oświacie, połączenie wysiłków przedstawicieli różnych stref działalności, oraz planowanie efektu synergetycznego jako swego rodzaju gwarancji uzyskania fundamentalnie nowych rozwiązań w sprzyjających okolicznościach może zapewnić sukces na odpowiednich rynkach.