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Educational strategies in engineering education (on the example of Tomsk Region)

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Abstract

Contemporary world trends of societal development dictate the necessity of the search for new strategies of development engineering education in Russia. The emergence of new educational megatechnologies and metamaterials sets a goal of forming the system of continuous and anticipating education the content of which is shaped on the basis of foresight of prospective demands to a human as a subject of various kinds of social activity and orientation towards technological progress. In this circumstances, the shaping of forms of thinking becomes crucial part of the of content of education, and human and his consciousness are put at the center of educational process. The primary goal of this article is to demonstrate the possibilities and reflection on the first results of new paradigm of anticipating education in two technological universities of Tomsk – Tomsk architecture and construction university and National Research Tomsk Polytechnic university. As a result of application of elements of anticipating education in construction industry, establishment of creative environment, close cooperation between technological universities of Tomsk as well as realization of concrete students project initiatives in the field of high construction technologies, concrete results in the sphere of improving competitiveness of Tomsk Region as a subject of the Russian Federation were achieved. Scientific works and innovational products that were created with contributions from Tomsk universities are in demand at both internal and external markets.

Keywords: Higher education, megatechnologies, educational strategies, engineering education, metamaterials, anticipating education,Tomsk Region.

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1. Introduction

The processes of globalization add to transformation of the structure of world economy, politics and culture integrating and unifying educational systems of various states. On the one hand, processes of standardization of education across the world contribute to the formation of more flexible educational systems within integrated global educational space. On the other hand, through revising their state priorities national governments pose issues of improving competitiveness in global arena before their national educational systems. This trend drives universities to shape deeper conceptual approaches to development of curriculum, to more closely follow activities of competitors, to modernize contents and methods of training, knowledge and skills, educational technologies in the context of accomplishments of contemporary science in various its fields, putting an emphasis on raising the quality of educational process itself. According to state of progress of information society each university designs its specific methods and forms of academic activity without compromising its quality and orienting towards global educational experience. At the same time, preservation of national values specificities of education remains pertinent. This demands deeper adaptation measures, revision of strategies and mechanism of educational management and bringing it in line with rapidly changing role of education in the world.

This problem is particularly pertinent to Russian Federation where one can observe an ongoing search for a new system of education, new approaches and methods that will become more competitive and effective. In particular, this concerns universities specialized on technology and construction. Their educational programs can become alternatives to renown technological universities of Northern America, Europe, Asia and Australia. Russian engineering education is currently attempting to work out a new paradigm of its development that takes into account traditional fundamentality of theoretical training of Soviet and Russian systems of education as well increasing role of knowledge in information society, contemporary educational technologies and demands of the labor market. The immense social significance of theoretical knowledge was particularly underscored by renown American sociologist D. Bell. To a large extent this owes to the fact that only in the beginning of the second half of 20th century the convergence of science and engineering had occurred, and drastically transformed the essence of technology – it became more intellectual (Bell, 1973). Hence, the study of the problems of formation of the new system of "anticipating" engineering education in Russia and conceptual generalization of main currents of its development in Russia and across the globe becomes pertinent.

2. Education and synergy: Conceptual bases of interaction

The special role in the process of formation of the new paradigm of education belongs to the formation and realization of integral educational process that is in line with trends of development of contemporary scientific knowledge. Differentiation of sciences and synthesis of scientific knowledge, application of universal methodology by various scientific disciplines is the basis for application of synergy in contemporary educational process. First of all, synergy as a theory of interaction between parts and the whole, the whole and environment, allows organizing the process of cognition of objects of wild life and inanimate nature, to determine laws of self-organization and co-evolution of even the most complex systems (Haken, 2003). The significance of synergy lies in its inter-, multi- and transdisciplinary character. Interdisciplinarity encompasses cooperation of various scientific fields of knowledge in a study of a certain phenomenon. Multi-disciplinarily includes simultaneous study of particular subject from points of view of various scientific disciplines (Knyazev & Kurdyumov, 2007). Transdiciplinary study is characterized by transfer of knowledge schemes, ideas and objective laws from one discipline to another. All in all, synergy is the basis for emergence and development of new scientific fields in various disciplines (Vereshchagin et al., 2009).

Scientific knowledge is gradually integrated into a system of interaction between science and technology. This phenomenon is called technoscience. Technoscience is a concept of integrated field

of knowledge based on close interaction of fundamental and applied science with an emphasis on technological and social aspects of scientific knowledge. Rather than Truth, technological efficiency is in the foreground of this concept. Knowledge represents project of action and construction becomes the model of acquiring knowledge. The most notable examples of realization of technoscience projects are NBIC –technologies which have a potential of becoming a new stage in the human evolution. NBIC-convergence is based on a principle of synergetic combination of four scientific and technological fields: nanotechnologies, biotechnologies, information and cognitive technologies as well as social technologies. All technologies interact in a synergetic way, complement and enhance each other creating unprecedented means of transforming human and his civilization. NBIC-convergences open new opportunities of evolution as a consciously directed process of transformation of human nature. NBIC technologies are capable of creating the way of scientific and technological advancement that can explode the lifeworld of human to an extent of complete transformation of human nature and identity.

For example, in North America and Europe alike special programs of development based on NBIC technologies were designed for the purpose of improving human capabilities. The American program Converging Technologies for Improving Human Performances (2002) was launched by M. Rocco and W. Beinbridge. A. Nordmann and George Khushf designed the EU program called Converging Technologies for Improving Human Performances. (Chernikov & Chernikova, 2012).

Other important fields of development of scientific knowledge and crucial megatechnologies are picotechnologies and femtotechnologies. There are well-known ideas of professor, doctor of technological sciences Alexander Bolonkin on the theory of femtotechnology that will substitute nanotechnologies. Femtomaterials will be able to withstand extreme temperatures of millions degrees without changing conditions and letting heat go away. They will be completely chemically stable, not exposed to corrosion and weariness. New picotechnologies applied in production made possible the acquiring of images of certain atoms and to graphically show the shifts in lattice points determined by divergent polarization. The study group was formed the German Institute called Forschungszentrum Jülich supervised by Knut Urban who is the director of Ernst Ruska-Centre, managed to obtain and an image of crystal lattice with an unprecedented high definition of 28 picometers of, or 0,038. This breakthrough was made possible by the usage of new method of electronic microscopy.

Therefore, the creation of new megatechnologies and metamaterials sets a goal of formation of a new system of engineering education which will the lead over production. It is precisely the formation of “anticipating education” that will be the foremost important goal of the development of both general and professional education. The system of education is one of the most crucial social institutes that functions in close interconnection with other social institutes and sub-systems. The notion of “education” (obrazovanie) itself is linked to personality and is derived from the root “obraz” (image). Hence, education is also a process of creation of images of self and environment in person’s mind. Taking into account demands of current system of education and development of technological progress, the main goal of education is to make engineers conscious of representations and images of production – the creation of material goods and services that are necessary to sustenance and development of society. This can be achieved through teaching skills of working with particular kind of production to future engineers. This involves special training in working with particular kinds of technology the practical application of which facilitated the production of a certain good of service. In this situation, education reproduces certain socio-cultural patterns of professional activity, research, knowledge etc. Contents, technologies, methods and forms of education are aimed at students’ learning of the abovementioned patterns. As a result, there is a typical situation when not the production but the creation of material goods and services serves a human, and a human serves to impersonal production. This state of affairs negatively influences both human and production. The system of interaction of human and production becomes dull, loses flexibility and capacity to react to innovations, human becomes incapable of applying technological novelties. All that considered, human is lost as personality and subordinated to the necessities of production and scientific and technological progress. As a result, on the one hand, we have underdeveloped personality warped by

narrow professional education and routine, repetitious professional activity. On the other hand, - stagnation in the development of production because the level of education of engineers adapts exclusively to instantaneous needs of production which sharply limits perspectives of its development (Novikov, 2000).

In XXI century the role of science and education will significantly grow because the humanity will face problems the resolution of which will be impossible without appropriation and mastering of growing knowledge. In addition, the anticipating character of education demands principally new ways of organization of the process of training engineers, shift of emphasis from reproductive activity of students to productive and searching activity. The system of anticipating education based on methodological principles of synergy has to become as open and non-linear as possible, aimed at involvement in resolving problems through mechanisms of social partnership, innovational institutions, scientific production complexes and socially significant projects etc. The content and character of engineering education should meet the demands of technology which are non-existent at the moment but those which have potential of real application. Apart from that, higher education should train specialists that are capable of resolution of not only actually existing problems, but of foresight of those problems that the humanity will face in future. Human and his consciousness should be at the center of educational interest.

3. Ethical principles of formation of personality as fundament of training engineers of future

The anticipating strategy of professional education as “an idea of synergy” reflects the orientation of educational process and its content towards anticipating development of personality of a would-be specialist, contributing to his preparedness to modeling future, foreseeing alternatives of development, setting and fulfilling innovational professional goals. The important role in the process of formation of new paradigm of educational system belongs to setting a goal of training and nurturing a human. This goal is not confined to the assemblage of knowledge and skills, but encompasses the creation of conditions for free personal development. Thus, while training specialist that are capable to react to challenges of future, special attention should be paid to basic culture of specialists and respectively, formation of competences that facilitate application of acquired knowledge and skills in practice.

For instance, in the process of training construction engineers one should take into account current achievements and demands of construction industry. Any kind of created material of both technological and construction character should meet the following criteria.

- Technological availability and efficiency of production.
- Biocompatibility and ecological safety (nature balance).
- Economic expediency.
- Resource and energy saving (Gorlenko & Sarkisov, 2011).

According to these demands, needs, conditions and quality of training of construction engineers should be articulated. Also, it should be put in the context of methodological base of the paradigm of anticipating education. Current production is in need of multi-tasking specialist that is capable of orienting in various fields of knowledge which in turn takes into account problems of construction and contemporary achievements of science and technology, possibilities and approaches of using nanoparticles and megatechnologies. Among them are the following.

1.Exhaustion of high quality construction raw materials. This leads to the necessity of expanding raw materials base and organization of new technologies and methods of acquiring high-quality raw material;

2. Accumulation of technology-related and irregular raw materials. Thus, any kind of raw materials should be used on the basis of new achievements, technologies and knowledge of its refinement,

modification, application and potential of further use. It is typical when traditional raw materials reservoirs as a result of its exhaustion, are used less and less, and the usage of new raw materials is prevented by incompetence of construction engineer;

3. The emergence, as a result of scientific discoveries, of principally new technologies of refinement and modification of any kinds of raw materials and acquiring compositional and structural materials of diverse technological function with assigned set of characteristics;

4. Managing processes of hydration, solidification and destruction of structures of cement rock, and other materials based on it, at femto , pico, nano, micro and macrolevels;

5. Application of 3 D and 4D technologies in computer modeling of construction. Contemporary society is in need of specialists who have new knowledge and mastered practice of application of these technologies. At the same time, the main trend of development of technological progress should be taken into account. This trend is connected with the process of simplifying technologies and simultaneous sophistication and mechanization of equipment. For this equipment to be used one needs to develop not a user skills but designer.

6. The creation of flexible system of professional orientation of youth.

7. The development of new professional standards of training future construction engineers that facilitate the acquiring of competences by them. These competences should be in line with technological novelties and innovations and also should be capable of resolving most pertinent practical problems.

Therefore, it is precisely human that is at the center of these intellectual searches. That is why, everywhere, even in the most problems unrelated and abstract problems moral and ethical principles dominate. Obviously, upbringing and education take their roots in spiritual and ethical traditions of cultures (Kartashova, 2015). Therefore, all kinds of changes in education are directly linked to dominating moral values of society at this point in time. Authors of this article state that material for the sake of material view is of little significance in the context of formation of humanitarian bases of world societal development. Synergic combination of composition and technology of acquiring materials should not contradict cultural and ethical norms both in form and in essence. It is not experience that is the basic criterion of truth but morality. And this imperative should become a criterion of evaluation of any kinds of future technologies.

4. The experience of formation of anticipating education in construction industry of the Tomsk Region

It is obvious that one of the key subjects and objects for maintaining leading positions of Russian in international arena in the sphere of engineering training of specialists is the “creative class” – high qualified and creative individuals with functional, moral and active citizenship position. According to Richard Florida, in the contemporary model of “economy of knowledge”, the economic growth is determined by creative people who prefer places that distinguish themselves as diverse, tolerant and open for new ideals (Florida, 2002). The formation of creative class is possible only in certain socio-cultural environment. This environment speed up the exchange of knowledge and as a result leads to higher rates of innovation, creation of high technology industries, new workplaces and economic growth. Currently, Russian regions demonstrate active growth of creative milieus that significantly influences regional educational processes. For example, Tomsk Region is one of the subjects of Russian Federation, that is located in Western Siberia and it has an advantage of development of construction and educational industries. The greater part of the territory of Tomsk Region is taiga and therefore is hard-to-reach. Woods occupy 63 per cent of the region. Rated wood-cutting of “Siberian Athens” is 41 million cubic meters. Tomsk Region is fast developing region with average income of 33.2 thousand rubles per month (for 2012) (Tomsk Region Development Strategy till 2020). The regions traditionally positions itself as one of most important oil, gas and construction regions and leading scientific and

educational center of Russia. There 6 state universities in Tomsk, including 2 national research universities. Also, there 6 institutes of Russian Academy of sciences, 6 institutes of Russian academy of medical sciences located in Tomsk. Since 2007 the share of educational complex in gross national product remains over 5 per cent. Tomsk region is one leading regions that develop the economy of knowledge.

For the last 25 years, the strategy of anticipating education and establishing creative environment has been actively developed. To begin with, Tomsk universities pay special attention to the formation effective organization of anticipating education through development of cognitive activities of students, formation of ability to independently acquire knowledge with cooperation with other students. Also, all these measures significantly raise the economic attractiveness of the region. For example, the realization of project on establishing the Center for education, research and development (Southern part of the region), the effective natural resource development and the creation of center of competence for their acquirement and refinement (The northern part of the region) will provide balanced territorial development. Apart from that, the project will contribute to the expansion into world market of high technology products and intellectual services (Tomsk region in figures, 2014).

A good example of practical application and development of anticipating education in Tomsk Region is the realization of the project of socio-economic development of territory – TOR (2014), which is realized in cooperation with Tomsk universities. The project entails introduction of special legal status on the territory of the closed administrative territorial unit of Seversk. This legal status includes special legal regulation of entrepreneurial activity and facilitating socio-economic development of city and providing comfortable living conditions. Nowadays, the TOR project has become one of the most important instruments of raising competitiveness and investment attractiveness of the region (Territorial body of the state statistics in the Tomsk region, 2014).

Another example of implementation of anticipating education in the region was the forum of young scientists called U-NOVUS. Through several years of its activity, the forum has become communicative, discussion and creative playground for young scientists, inventors, entrepreneurs in the innovational sphere. The Tomsk forum gives an opportunity of not only exchanging experience of production of innovations, attracting investments , but also it provides a playground for discussion and educational projects that are meant to facilitate knowledge acquirement. The program of U-Novus includes public lectures of leading scientists, creative laboratories, excursions, screening of scientific films, master classes, exhibitions and contests. The predecessor of the forum is special technology development economic area the experience of which has become one of the most successful in Russia. This area was created in 2005. Another predecessor of U-BOVUS is Tomsk technological park. 2015 marked 25th anniversary of the technological park. For further development of the system of anticipating innovational education and elaboration of the special innovational socio-cultural environment in Tomsk, it is planned to create innovational territorial center “Ino-Tomsk” that will facilitate new round of development of fundamental, applied and corporative science, in cooperation with scientific and educational complex and real sector of economy.

One of the examples of real results of implementation of anticipating education in Tomsk Region is construction industry. The construction industry is currently on the most rapidly growing in Russia. According to the results of Russian-Chinese negotiations (2015) on cooperation, Tomsk Region and Tatarstan were the only two regions that signed the documents. A contract on construction of timber industry in the village called Beliy Yar at the expense of foreign investments the total amount of which is 50 billion rubles, was signed

Since the end of 90s the small businesses has been created by alumni of Tomsk universities. A large part of business specialized on high-quality products and conducted research. Thus, the vast majority of small and medium-sized businesses that focused on construction emerged on the basis of the results of scientific findings made in universities and scientific research institutions of Tomsk Region.

However, financial problems competitiveness and shortages in qualified staff are significant disadvantages of innovational infrastructure of the region.

All that considered, Tomsk Region has a significant potential for further development of innovational environment on its territory. This environment serves as basis for formation anticipating education. Numerous creative playgrounds and significant infrastructure of regional innovational economy serves as firm basis for interaction of education, science and production and supports the attraction of students to realization of projects. Real creative activity, active scientific search, the usage of the last achievements of science and technology, application of new technologies serves as a good basis for self-perfection and self-cognition.

5. Projects of Tomsk universities in construction sphere as a basis for educational activity

Tomsk polytechnic university and Tomsk University of architecture and construction serve as integrating basis for the establishment of close ties between science, education and construction industry of the region. TPU holds a status of national research university and this in turn sets goals of raising effectiveness of educational and scientific activity on the fundament of principles of integration of science and education, facilitating effective transfer of technologies in construction, realization of a broad range of fundamental and applied research projects as well as training of qualified personnel for construction industry and perfection of the system of training of masters and higher qualification. Apart from that, TPU along with other 14 universities was shortlisted as “leading university” that will aspire to enter top 100 list of the best universities in the world.

In turn, Tomsk University for architecture and construction (TGASU) is strong scientific-educational complex which insignificant measure determines the construction politics in Siberian region. Universities specialties embrace all cycle of works of construction – ranging from architectural designing, economic justification of building, edifices, roads, reconstruction and renovation of buildings and listed buildings, technological expertise of dwelling stock and management of real estate, technological facilitation of construction and mechanization, safe methods of running technological processes to environment control of construction. The university takes part in formation and realization of national projects and programs in Tomsk Region and Siberian region as a whole. Scientific schools of TGASU and technological and research projects carried out by the university academic staff are recognized and desired in Tomsk Region, Russian Federation and abroad. In terms of quantity of scientific research the university occupies the second rank among universities of architecture and construction in Russia (Strelyaeva & Shirko, 2015).

These technological universities closely cooperate with each other in scientific, innovational and international avenues as well as in sphere of advanced training of specialists and, on a whole, in educational activities. Students of engineering programs are actively involved in projects of both universities. They realize their own initiatives in separate scientific fields. Their most recent collaborative project was the program called “Breakthrough” that was focused on training specialists for constructing atomic power stations. The agreement on strategic partnership was signed by Petr Chubik and Victor Vlasov. The funds of the 3-year project amounted to 300 thousand Euro. The project “Breakthrough” was successfully realized in Siberian chemical plant (SKhK). It was meant to investigate the ways acquiring new kind of fuel that will serve for atomic engineering after 2020. Pilot and demonstration energetic complex (ODEK) as part of reactor unit “BREST-OD-300” with transformer nuclear fuel cycle is developed. Also, the production of uranium and plutonium (nitride) fuel for reactors working on high-speed neutrons was launched in Seversk.

Yet another avenue of cooperation between two universities is the usage of glyoxal. Due to low toxicity and high reactivity, glyoxal is used chemical, oil, gas, woodworking, textile, leather, pharmaceutical, geological as well as construction industry. In construction, glyoxal is used for producing high quality construction mixes. Tomsk universities actively cooperate with “Novokhim” that is the only factory that produces glyoxal in Russia on the basis of unique technology of synthesis

which is unparalleled. Also, Tomsk University collaborate with another producer of glyoxal, the company called "Glyoxal-T" which runs experimental-industrial production of glyoxal with the use of catalysts of new generation. Apart from that, the company works on creating glyoxal-containing materials [13,105]. The glyoxal aqueous solution, namely crystallic glyoxal and modifier MD 218-U is used for production of glyoxal. The usage of glyoxal MD 218-U the toxicity of formaldehyde-containing resin drops. Due to its liquid character, the modifier MD 218-U is easily put into composition. It also facilitates the bettering of physic-mechanical property of the end product. This modifies was successfully tested in production of materials, clue, paint-and-coatings industry for increasing adhesion, durability and humidity resistance. Due to connective capability intrinsic to glyoxal, the supplement MD 218-U adds to increasing effectiveness of interaction of construction materials with surface. Adding of 1-3 per cent of this matter (solid residue) increases the adhesion of clue by 70 per cent on average. Beyond that, there is no necessity in extra equipment for the use of the modifier MD 218-U.

As can be seen from the above, the cooperation between two leading Siberian universities – Tomsk state university of architecture and construction and Tomsk polytechnic university, in the sphere of construction and engaging students in realization of projects in field of high technology. Also, this cooperation develops students' ability to organize their own research projects, to apply them in production. Apart from that, the collaboration between universities addresses the issue of engaging students in work with new technologies, teaches them independent thinking and responsible decision-making determined by needs of human. Both universities have many perspective avenues of cooperation and experience of many of them can become a basis for development and adaptation of new educational programs for future engineers.

6. Conclusion

In conclusion, it should be noted that first results of implementing separate elements of strategy of anticipating education in technological universities of Tomsk can be referred to as fruitful. The formation of territorial creative socio-cultural environment actively adds to the development of anticipating education in Tomsk Region and overall modernization of educational activity of universities in engineering training of young specialists. Active implementation of elements of anticipating education in training processes of construction industry and close cooperation of technological universities of Tomsk contribute to active participation of students and alumni in developing of innovations, raising competitiveness of Tomsk Region as an innovational subject of Russian Federation. Active student engagement in projects in the sphere of high technologies, work with megatechnologies and metamaterials contribute to the formation of qualities of mature personality among future engineers and lay ground for their further personal advancement. Tomsk universities should pay more attention to developing of educational programs oriented towards new achievements in science and technology. It should be also noted that authors did not intend to resolve global issues in construction industry and current construction and technological material science, but tried to cover some aspects of future educational strategies in their indissoluble interconnection with cultural and ethical norms of contemporary society.

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