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Experience in applying educational technologies to the integrated system of engineering students

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Abstract

Some evolutional aspects of the institution currently known as Siberian State Aerospace University are presented as an example of degradation of the integrated system of engineering training and the entire engineering education on the way from planned to market economy. Prospects for some educational technologies expected earlier to raise university graduates' competency are found out to be doubtful. The analysis of labor market requirements to alumnae shows that no traditional educational technology allows them reach the competence level required by the modern labor market. The existing system of university engineering education is criticized as a whole. Better prospects for preparing engineers have continuing professional training systems at enterprises that still pursue innova-tive projects. The current activity of such a system at Information Satellite Systems Joint-Stock Company as to preparing engineers along the "School-University-Enterprise" line is briefly outlined.

Keywords: Engineering education; Educational technology, Continuing professional training.

1. INTRODUCTION

Since recently the ever increasing role of innovative-type industry is observed in technologically developed countries, and university graduates are usually considered to be the main guiders for innovations. However, there are a number of serious problems facing engineering education

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globally, even if the educa-tion is acknowledged as good. First, it is about the discrepancy between engineering practice in industry and the goal setting at universities. To improve the quality of teaching at universities a variety of methods are used but gradually it becomes clearer that university education alone can not replace the education obtained “at a work site”.

Also, constant technological innovations can rapidly lead to inadequacy of any university education, no matter if it is good or bad. Trained in high school within the framework of a certain technology, engineer-ing graduates can lose their competence if production shifts to a new technology, which necessitates their continuous qualification adjustment. Therefore, the more the innovative-type production prevails, the more important continuing engineering education becomes to expand engineers’ learning over a lifetime.

Global problems of engineering education belong to Russian engineering training but here specific national problems aggravate the situation. First, until now the obsolete engineering education system cre-ated within the planned economy and fitted out to satisfy its specific needs remains in its main features. On the one hand, it can not provide engineers required by the current labor market; on the other hand, it stays not in a good form of Soviet times but is rather degraded during the last two decades. The graduates’ quality long ago started to diminish, and not only compared to the current world level but in some respects abso-lutely.

So, we can not expect a large number of creative or just good engineers from the existing system of engineering training. They will appear not before the existing system will change, and to make it, as President of the Russian Association for Engineering Education wrote: “…cardinal changes in the system of engineering education are needed” (Yu. Pokholkov, 2010). Moscow distributors of financial flows who are appointed responsible for the high-tech development anticipate colossal government investments in innovative projects will make a breakthrough but this refers to their own prosperity rather than native engineering improvement.

At the same time, to some degree we can reckon on the development within those systems of continuing professional training which exist at enterprises that until now are engaged in some kind of innovative activity. A good example is Information Satellite Systems Joint Stock Company -- Russia’s leading space enterprise specializing in design, development and manufacture of high performance spacecraft and satellite systems. Below we present some results of more than two decades of experience in applying some educational technologies to engineering students at the institution currently known as Siberian State Aero-space University who since the mid-1960s were infiltrating the Company’s structure. This experience witnesses in favor of continuing engineering education within such enterprises rather than existing univer-sities.

1.1. The integrated training system: a “sandwich-program" adapted in the USSR.

Siberian Aerospace University (SibSAU) gives us one particular but impressive example of the general rise and fall of all the Soviet engineering education system. In this institution the system of engineering education was and until now is specified as the integrated training system (ITS). Originally this system became known since 1903 in England as "sandwich-program" and since 1906 in the USA as «cooperative program». It emerged as an educational program with deep integration of educational process, science and industry.

In the USSR there were attempts to introduce this system in the 1930-ths with not much success. In the 1950-ths the arms race gave a new boost to this process and as a result several versions of ITS appeared. The most well-known among them was the "factory - technical college" system intended to train engineers mainly for the largest soviet military plants (base plants). From then on this system played an important role in preparing engineers and was developing positively until the USSR disintegrated in 1991.

It was featured by the utmost rapprochement of educational process and industrial activity. Conse-quently there was a significant reduction of time necessary to form specialists with the knowledge of manufacture, necessary skills needed for engineering activity at industrial works, and operational experience within a labor collective. An educational institution took active part in solving current industrial problems, while a base plant on its part could link its infrastructure and leading experts to students training, thus allowing its human and material resources for preparation of engineers.

There were some other advantages, too. Equipment and devices available at a base plant were widely used in the educational process, and students had the right to use its scientific and technical libraries. Also, working students got the same social privileges and guarantees as the plant personnel; their period of work was included in their seniority, etc. This system also favorably differed from that of a regular technical high school since no expenses were required on the part of an educational institution to carry out students' industrial practice.

The SibSAU history offers a unique illustration to the evolution of ITS in Russia. The factory-technical college ("zavod-VTUZ" in Russian) created in 1960 at the Krasnoyarsk Mechanical-Engineering Works (Kras-mashzavod) had initially been called on to reduce the shortage of qualified engineering staff there. This task has been basically solved, and the emerged zavod-VTUZ almost completely provided one of the largest Soviet space-rocket plants with the engineering staff of required specialties.

The most significant feature that distinguished zavod-VTUZ from regular Soviet engineering high-schools was a special form of engineering-industrial practice (so-called "working semester") that allowed stu-dents to get better acquainted at the base plant with basic manufacturing works and specialties, attain more skills in the engineering-industrial activity sphere, and prove in practice theoretical knowledge gained scholarly from subjects and courses of specialization.

The length of their working semester considerably exceeded the duration of usual students' industrial practice in regular soviet engineering high-schools. While the overall study time in zavod-VTUZ was 5 years and 10 months, the total length of students' labor activity within the working semester framework lasted 2 years and 8 months.

All students went through the following two stages of the engineering-industrial practice:

1. Working stage for juniors. At the preliminary students studied the introduction into their specialty course and got a general acquaintance with the base plant and main faculty. In the main part of the first stage students were linked to workplaces while periodically changing main working professions. At this stage students participated as workers in all spheres of industrial and public work; mastered basic working professions in the sphere of their future engineering specialization; got acquainted with the base plant structure, basics of labor legislation, economy, organization, rights and duties of the working staff, features and diversities of industrial activity at the base plant.

2. Engineering stage for seniors. At this stage students mastered professions of technicians and engi-neers according to their specialization, applied, proved and fixed in practice the knowledge they gained from scholarly studies, participated in all spheres of technical and public work typical for technicians and engineers, and adapted themselves to industrial realities and engineering activity. Finally students were trained at nonproductive posts in the base plant departments, bureaus and sites according to their specialization.

At both stages the practice was directed towards maintaining the continuity and the right sequence of mastering subtleties of professional work as students passed consecutively through the following se-quence of jobs: worker's pupil → worker → technician → engineer. Besides their main industrial work at both stages of the engineering-industrial practice, students at the same time attended classes, took part in seminars and carried out individual assignments according to their timetable.

As for scholarly teaching students, here like anywhere in Russia mainly traditional educational me-thods typical for regular engineering high-schools were and in fact are used until now. Being practiced earlier within though authoritarian but well-ordered and thus effective educational systems, in concert with a rela-tively high level of pre-college education, these methods allowed Soviet engineering education produce eligible graduates whose diplomas were even acknowledged in some other than Soviet block countries. Moreover, in some, though quantitative, aspects, Soviet engineering education at times even surpassed those of technologically more developed countries.

Also, one should bear in mind that in the planned economy epoch graduates got job through the planned distribution and had no right to desert their workplace for three years that actually was the time when they were becoming professionals. In this way the planned economy allowed graduates to be under formal or informal trusteeship of leading industry experts which compensated many high-school shortcomings and facilitated even very incompetent graduates to get necessary professional skills at their workplaces step by step. Therefore the educational methods that were used in high school then were quite a good fit to provide Soviet economy with graduates necessary to fulfill its special needs.

1.2. Degradation of the integrated training system and the whole engineering education

After the USSR disappeared and planned economy was immersing into chaos hard times came for all former soviet high technical schools which were created to provide economy with their graduates and thus were connected with it via innumerable links. The planned economy crash affected even more the "factory-technical college" system where an educational institution actually represented one big factory shop designed to produce engineers mainly for a base plant. Since then the constructive development of the integrated training system stopped and its degradation started.

In the institution at the “Krasnoyarsk Mechanical-Engineering Works“ it was degrading in parallel with the feverish as if in agony changing the institution’s names: “zavod-VTUZ” (1960-1989) □ “Space machines institute” (1989-1993) □ “Siberian Aerospace Academy” (1993-2001) □ “Siberian State Aerospace University” (2001- nowadays). Each renaming was proclaimed pompously as though symbolizing a new achievement along the road of progress while in fact it was nothing but imitation of real progress as often happens in Russia. All those changing planks and pretending to be universities only veiled the ever worsening situation at the same time facilitating the high-school leadership doing their own businesses.

So, year by year the state of this rather developed in three decades and as a whole successfully func-tioning system was getting worse. However, after the USSR disappeared, not only the integrated training system but all the engineering education started reducing to rubble. The continuous shrinking of the planned economy affected engineering high-schools very badly. It did not mean emerging a full-fledged market economy but forced higher education as a whole to be guided more by though praiseworthy but quite irrelevant examples of educational systems from more prosperous countries with market economies. In particular, much greater independence of universities in technologically more developed countries substantiated decentralization of native high-schools.

Having got the right to make decisions themselves, high-school bosses started to make decisions that were optimal not for the institutions they run but mainly for themselves. This is no wonder taking into account personal features of those who were appointed to their high post by Soviet “party-and-government” decisions, and only by chance turned out to be at the top when the USSR collapsed. Enough to point out that many of them made use of their posts not to try solving stockpiled problems of supply and management, improving the educational process, etc, but mainly for improving their own prosperity. And they were feeling brave since were not very much afraid to be dismissed from their posts.

As a result, no new engineering education system emerged after the last two decades of turmoil, thievery of the state property and corruption. Until now, the obsolete engineering education system created within the planned economy framework and fitted out to satisfy its specific needs remains. As President of the Russian Association for Engineering Education wrote: “…this obsolete system…was a good fit for the Soviet economy, and performs well in totalitarian regimes” (Yu. Pokholkov, 2010). However, now it stays not in a good form of Soviet times but is much degraded. While many Soviet graduates from such a system of training could be good engineers and some of them even become conductors of scientific-technological progress at least on the condition to be supplied with necessary materials from abroad, now native engineers hardly would be able to make new devices or projects due to a number of reasons.

First, all the time the gap grows between the level of global scientific and technological achievements and native engineers' limited abilities to comprehend and master them. Also, the university graduates' contingent is deteriorating year by year, and not only compared to the current world level but in many respects absolutely. The graduates' level decreasing became especially noticeable since recently when the new generation raised and schooled already after the USSR collapsed, started to enter universities. It's not only about their limited aptness to work after graduation but also the learning ability of engineering students, which causes much greater anxiety.

1.3. Modern labor market requirements to university graduates.

Meanwhile, engineering graduates are now in a quite different position compared to the Soviet era. There is no more federally planned allocation to work for graduates with their subsequent gradual adaptation and development as engineers. Instead, now they have to compete at the labor market, and to be successful there means not enough for them to possess special knowledge, have talent to put that knowledge into practice and skills of its use. The modern labor market demands graduates of quite another kind, that is, those who must be able to solve the problems set before them as soon as they get a job or after a very short period of adaptation. In general, it turns out that traditional educational methods suitable for the planned economy are not a good fit to prepare graduates for the labor market.

The analysis of labor market showed (Authors, 2010) there are 32 major requirements to engineering graduates in total which can be subdivided into three groups: 1) graduate's professional level; 2) graduate's personal qualities; 3) graduate's communicative abilities. The first group includes eight competencies such as technical or functional knowledge, etc. The second group covers 14 competencies like persistence, initiative, responsibility, etc. The third group of requirements includes ten abilities such as ability to understand, perce-ive new ideas, readiness to listen to others' opinions, etc. Here only the basic competencies required by the labor market are mentioned which does not exhaust their full set.

The complex evaluation of these three groups of competence parameters and introduction of the integral competence factor allows quantitative estimation of graduate's competence level. After eliminating all insignificant parameters in order to estimate the total graduate's competence only seven primary quasiindependent parameters remain: technical, functional, and general knowledge; initiative; persistence; responsibility; engineering talent. According to the calculation procedure each primary element contributes to the integral competence coefficient with a certain weight equal to the factor of relative importance multiplied by an expert estimation grade. Excluded secondary competence elements which to some extent characterize student's competence, too, are connected with and if needed can be derived from the primary elements.

So, if we try to raise the competency of graduates in order to match market requirements, first it is necessary to pay attention at each of the seven primary competency constituents. To enhance engineering talent is difficult enough; however, we still can make a proper selection among university entrants, besides, try to develop their talent in university. To increase general knowledge does not seem a big problem, and the needed level of technical knowledge can be reached by traditional educational methods. More difficult is to enhance responsibility and persistence. The main problems, however, are with functional knowledge and initiative which is crucial for developing engineering creativity.

2. RESULTS OF THE RESEARCH

After the USSR collapsed, on the one hand, chaos and degradation in high schools started. On the other hand, greater opportunities emerged for pedagogical experimentation with educational methods or, as they are used to say now, educational technologies as feasible means to raise the students' competence level. Briefly outlined below are those technologies that were the subjects of pedagogical experimenting by one of the Authors (2006). To some extent they are still used until now while teaching such subjects as Applied Statistics, Modeling Systems and Processes, etc,

1. Full learning. This technology is associated with the mastery learning first introduced into American education by G. Carroll and developed by his successors -- G. Block, L. Anderson, et al (see e. g. Bloom, 1971, Robinson, 1992, etc). Until now it is used in American public schools where basically demands from students reaching a certain level of predetermined mastery on current units of instruction before being allowed to progress to the next unit. Thus, it is a process whereby students achieve the same level of content mastery but at different time intervals. In the USSR this technology was adapted in secondary school by M. Klarin (1989) and others. Adapted and being used in high school as full learning, it arranges the educational process so as to bring each student to a standardized, in advance accurately set level of necessary knowledge and skills. Two moments are essential here: a) the teacher's belief that all students can and should master completely the teaching material of a given course; b) the development of the full mastering criteria for a given course or its section. This technology was effectively used by one of the Authors, in particular, while teaching the 'Methods of mathematical modeling' course for the 'Technical operation of electric systems and navigation equipment' specialty. The results of examinations in two types of groups -- the control groups and the experimental ones where pedagogical experimenting with the full learning technology were carried out -- testify to this. The typical results of examinations averaged over a large massive of students are shown below (minimum grade point: 1, maximum grade point: 5).

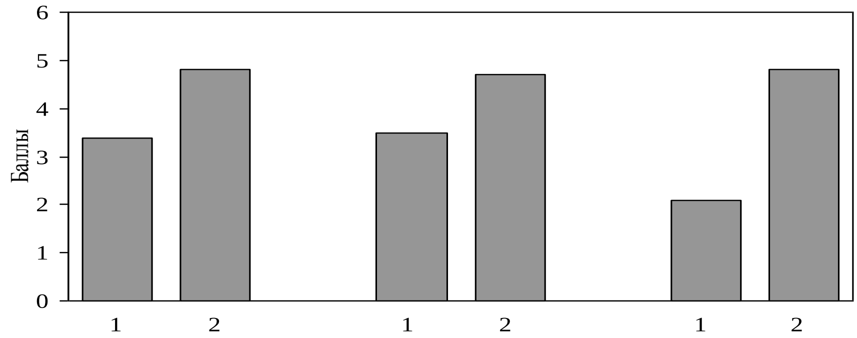
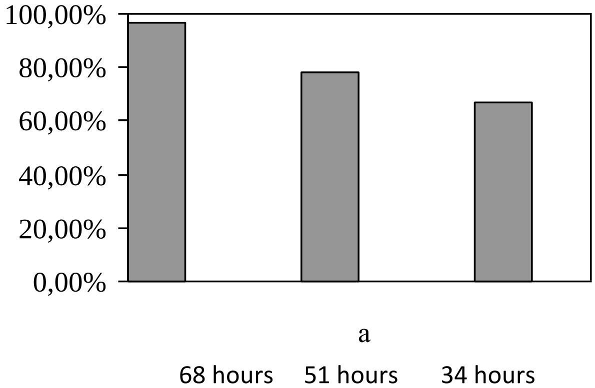


Fig.1. Averaged results of examinations for the groups of students subdivided in two subgroups:

(1) Control groups; (2) Experimental groups trained according to the full learning technology.

However, in spite of good results shown at examinations, our experience gives evidence that this technology is mainly limited to the simplest pedagogical goal-aiming categories such as knowledge and comprehension in the cognitive area of consciousness, and does not allow in principle reaching sophisticated pedagogical categories such as evaluation, analysis or synthesis which is necessary to develop students' creativeness. Also, it has some other drawbacks; in particular, the problems with scheduling arise.

2. Concentrated training (CT). This technology is recognized by some educators as stemming from Lozanov's theory and practice that once triggered an accelerated learning movement in the West. First used primarily for studying foreign languages (Bancroft, 1978) and mainly intended to hinder overlooking the teaching matter learned before, later it was spread out to many other teaching areas where various techniques not originally included in the Lozanov's theory were introduced. In high school (Ibragimov, 1995) the opportunity to concentrate deeper on the subject is provided by combining classes in certain course units and reducing the number of concurrently taught courses. Comparing this technology applied to a general course unit with the full learning we could see some positive effects since in such course unit the pedagogical goal-aiming categories both in the cognitive and affective areas are presented even though in a truncated form. This technology was used, in particular, while teaching the 'Automated control and information processing' course for the 'Automated systems of industry management' specialty. Our experience showed that this technology enables raising the level of general knowledge, responsibility and persistence. At the same time the lack of stable links between some educational goals while using this technology does not allow to achieve a needed level of competence even for the module (truncated) function of competence. Also, one of the problems of its use is the problem of scheduling. However, in general, it gives tangible results as to students' formal progress, some averages of which are presented below:



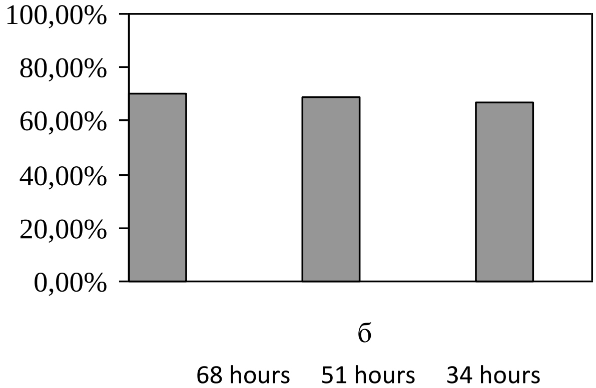


Fig.2. Typical dependence of number of students with higher grade points (4 ÷ 5) on the duration of classes:

(a) Experimental groups trained according to the concentrated training technology; (б) Control groups.

3. Pedagogy Workshops. In the West this technology is sometimes referred to as Inclusive Pedagogy with such characteristics as Faculty-Student Social Interaction (Baker, 1998), Activation of Student Voice (Bur-bules, 1991), etc. It was designed to essentially individualize training methods and advocate teaching prac-tices that embrace the whole student in the learning process, thus the "workshop" concept is pointed out. Although Soviet times were characterized mainly by authoritarian educational systems, this technology was used in Russia even then and now is used by some educators, too (Sokolova, et al. 1997). However, wider usage of this technology is limited since ultimately demands the presence of a high-qualified master-teacher which is not often possible. This technology was used by one of the Authors, in particular, while teaching the ‘Informatics’ course for the ‘Control systems for flying objects’ specialty. However, it turned out to be the most effective in pre-college preparation, such as in the lyceum incorporated in SibSAU. Our experience showed that if this technology is combined with concentrated training, a big positive effect can be achieved when teaching technical or functional courses. In this case it is possible to expand the general scheme of links between pedagogical goals in the cognitive and affective areas as much as possible. At the same time, like two above mentioned technologies, it mainly affects the cognitive area of consciousness. Besides, even if combined with concentrated training, often its good results can not be reproduced because of the crucial role of a master-teacher.

4. Training as educational research. Essentially this technology stems from John Dewey’s philosophies of schooling (Dewey, 2009) whose ideas have been especially influential in education during the first half of the last century. He argued that in order for education to be effective, content must be presented in a way that allows a student to relate the information to his or her prior experiences. When used in high school this technology has the necessary precondition: students must feel dissatisfied with the concepts they possess to date; their new concepts should be clear, plausible and potentially congruous with their former ideas and should help them solve technical problems and promote new theories. This technology was used, in particular, while teaching the

‘Statistical analysis of processes’ course for the ‘Technical operation for flying objects’ specialty. In our experience this technology demonstrated itself best at seminars in general course units. It mainly helps to improve general knowledge, responsibility and persistence. It was found out of little use in the first year of study, in the second year of study it starts to yield comprehensible results, and then its efficiency diminishes again as is shown below:

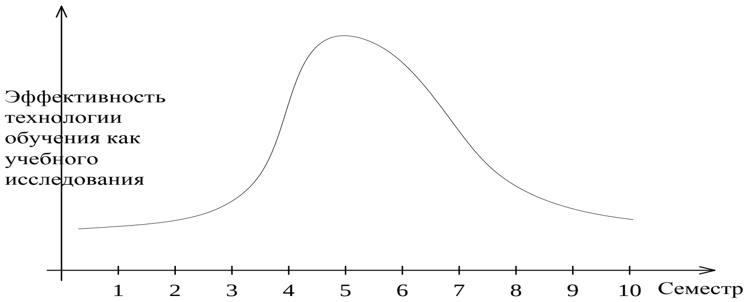


Fig.3. Typical dependence of the effectiveness of training as educational research technology on the time of its usage

Also, it turned out this technology leads to a large increase of students’ independent work time.

5. Collective brain-activity (CBA). Here we must first notice that, in general, in Soviet engineering education the teaching process was not much individualized but rather collective within students’ groups as compared to other countries where students usually have their own learning trajectory. Therefore, unlike other educational technologies, this one seems to be more or less of native origin (Vazina, 1990). On the other hand, since the time of lonely engineering inventors-intellectuals seems to have passed long ago, the idea of collective brain-activity when students guided by professors produce knowledge in teamwork is becoming more popular internationally. When used in the teaching process, this technology can be effective, for example, in newly introduced problem courses. In this case a file of problem situations is formed which is provided by the system of course units that are formed as intra-subject units. In spite of some advantages, results of exams don’t give evidence in favor of this technology:

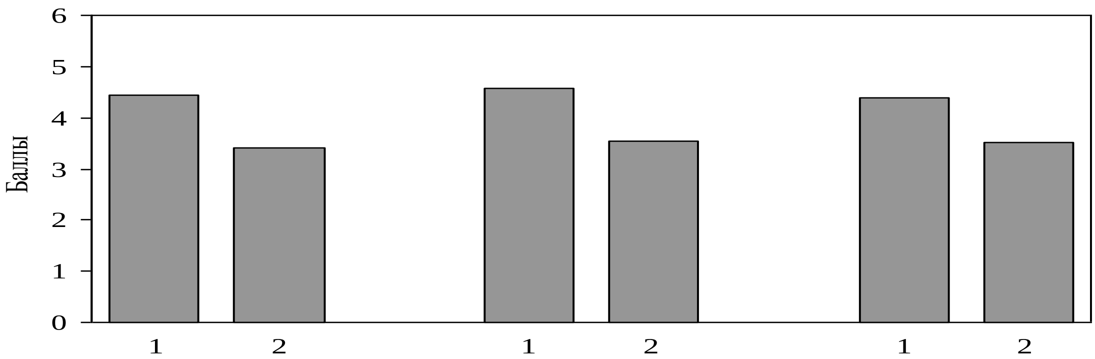


Fig.4. Averaged results of examinations for the groups of students subdivided by two subgroups:

(1) Control groups; (2) Experimental groups trained according to the collective brain-activity technology.

Also, this technology has fundamental restrictions caused by the essential impossibility to fully achieve many pedagogical goals in the cognitive and affective areas. In this case the general scheme of links between pedagogical goals breaks up so much that, in particular, in the cognitive area such pedagogical goals as “synthesis” or “estimation” become never attainable, and in the affective area the same is with “use of progressive technical orientations”, etc. On the other hand, if it is combined with the CT technology (CBA + CT), the truncated scheme of pedagogical goals again extends up to a comprehensible one. Moreover, if a master-teacher of Pedagogy Workshops is introduced in such combined technology (CBA + CT + PW), it shows very good results as, for example, was in the case of teaching the ‘Reliability of Technical Systems’ course for the ‘Technical operation for flying objects’ specialty.

6. Heuristic training. A Soviet version of this technology and its later adaptations (Hutorskoy, 1998) are based on heuristic learning process aiming at designing students’ own meaning, purpose and content of education, as well as the process of its organization, diagnosis and awareness. It also emphasizes the individual orientation of training but in this case the accent is transferred from the question “teach what?” to “teach how?” From this point of view this technology is of interest in high school, firstly, for general course units basically promoting the rise of competence level through stimulation of initiative and persistence. We used this technology in special courses mainly in order to help students preparing techno-economical proofs for their diplomas. Experimenting with this technology revealed that in this case the “Zeitnot” situation promotes achieving positive results, and up to 95% students successfully manage with their diplomas. However, in general, necessary conditions for that can hardly be fulfilled.

Some of the above mentioned technologies substantially individualize the educational process and were used with the serious intention to improve graduates’ competency during the transformation of Kras-noyarsk zavod-VTUZ to the institution known nowadays as SibSAU. Although since quite recently it started to seem clearer that many our efforts were in vain, the pedagogical experience that was acquired in the meantime in this institution might be of use for educators no matter where they teach no matter what. In particular, our experience showed that each technology has its own merits and disadvantages which are de-termined by how effectively pedagogical goals can be conjugated with each other and to what extent each can be fulfilled which is shown below:

Table 1 Degree of achievement of pedagogical goals. Symbols: (+) – goal fully achieved; (/) – partly achieved; (-) – not achieved

	Pedagogical goals										
	In cognitive area					In affective area					
EDUCATIONAL TECHNOLOGY	knowledge	comprehension	appliance	analysis	synthesis	estimation	perception	reaction	mastering progressive orientations (PO)	managing PO	developing PO
1. Full learning	+	+	/	/	/	/	+	+	/	-	-
2. Concentrated training	+	+	+	+	/	/	+	+	+	/	/
3. Educational workshops	+	+	+	+	+	/	+	+	+	+	/
4. Training as educational	+	+	/	/	/	/	+	+	+	/	/
5. Collective brain-activity	+	+	+	/	-	-	+	+	/	-	-
6. CBA + CT	+	+	+	+	/	/	+	+	+	/	/
7. Heuristic (under certain	+	+	+	+	+	+	+	+	+	+	+

Analyzing and generalizing the experience of applying the educational technologies mentioned above to a large variety of engineering students, we could draw the following conclusion. Whatever positive effect each of these technologies could have as to developing students' particular competencies, none of them allows reaching the total competence level required from graduates by the modern labor market because the degree of their influence on all the essential competence constituents is generally limited. The following table testifies to this statement:

Table 2 Educational technologies influence on competence primary constituents as to whether they provide labor market requirements or not. Symbols: □ - provides good enough, ∇- provides to a certain extent; ⊗- does not provide.

COMPETENCE PRIMARY CONSTITUENT / EDUCATIONAL TECHNOLOGY	Technical knowledge	Functional knowledge	Initiative	Responsibility	Persistence	Engineering talent.	General knowledge
1. Full learning	∇	⊗	⊗	□	∇	∇	□
2. Concentrated training (CT)	∇	⊗	⊗	□	□	∇	□
3. Educational workshops	∇/ □	∇/	∇	∇	∇	□	□
4. Training as educational research	∇	⊗	∇	□	□	⊗	□
5. Collective brain-activity (CBA)	∇	⊗	⊗	∇	∇	⊗	□
6. CBA + CT	∇	⊗	∇	∇	∇	∇	□
7. Heuristic (under certain conditions)	□ /Δ	∇	∇	∇	∇	∇	∇

From the above table one can see that the best results are as to raising general knowledge and the worst are when trying to teach functional knowledge or improve the initiative. In many respects this is be-cause of the fact that at a technical university the goal-aiming specificity in different fields of knowledge causes differences in educational goals in the cognitive and affective areas for general, technical and functional knowledge. For example, in the cognitive area, within the basic pedagogical category "synthesis" the generalized types of educational goals for technical courses include the ability to combine knowledge from different science areas in order to solve purely technical problems while for functional courses the same refers to solving technological problems, etc. Also, in the affective area the categories of educational goals for technical and functional courses coincide but differ from the educational goals for general educational courses. For example, for technical courses the «developing progressive technical orientations» educational goal includes a firm desire to master a certain scientific and technical direction while for general educational courses it means only learning a certain item of a concrete course section.

Some prospects to increase students' competence seemed to have methods of activating the educational process being combined with the working process. Experimenting with students studying problem courses showed that these methods can sometimes sharply increase the level of functional knowledge and the initiative. In this case responsibility and persistence grow too in experimental groups compared to control groups. It was also found out that the greatest gain in functional knowledge can be provided by the methods using venture games when the educational process is organized so that venture games make a throughout basis during all the training period.

Although such a process demands special preconditions, it could be implemented within the integrated training system of the former Krasnoyarsk zavod-VTUZ. However, the more this system was degrading, the more difficult it was becoming to implement such a process. In general, year by year it was becoming more difficult to combine education with work because of the steadily decreasing volume of the engineering-industrial practice, the smaller number of workplaces prearranged by the base plant for the working semester, etc. Therefore, now one can hardly even speak about the existence of the integrated training system at all. As a result of devaluation of the engineering-industrial practice that distinguished zavod-VTUZ, gradually this institution in its main features started to resemble a usual engineering high-school which is fairly degraded, too.

3. CONCLUSION AND RECOMMENDATIONS

In light of the above mentioned we can not expect many creative or just good engineers from the existing system of engineering training at universities alone. Instead, to some degree we can reckon on their more or less effective preparation within systems of continuing training at enterprises that are still engaged in any kind of innovative activity. An example of such enterprise is Information Satellite Systems Joint Stock Company (see ISS JSC web-site) where many SibSAU graduates work.

The continuing professional training system that once emerged and has been being developing here for several decades (Author, 2010) is intended, in particular, to provide the Company with creative engineering personnel. Since there is no more federally planned allocation of graduates to work, an important role in preparing engineers plays the corporate system of organizing pre-college training, training target students in higher education and training engineers at work which are interconnected all the way through thus forming the “School-University-Enterprise” chain.

The preparation of future engineers starts early with their vocational guidance in secondary educa-tion institutions where many things are being done: enhanced learning of physics and mathematics is introduced; curricula are more focused on the integration of science with engineering; regular meetings of the Company’s experts with pupils, parents and teachers are carried out; lectures by experts are given, subject Olympiads, competitions, excursions and other events are organized, target students are chosen, etc.

The preparation proceeds further when target students enter high school. While they gain theoretical knowledge at university based departments, in the Company Subdivisions they adapt to industry realities, are nursed in a corporate manner, do course and diploma works, etc. After graduating within the first working year young engineers pass compulsory coaching. Besides, target classes are organized for them. After the first and second year of their work they must prove their certification which results allow authorities to make a decision as to whether acknowledge their professional skills or not.

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