

Pedagogical Conditions of Ensuring Students' Readiness for Scientific Researches—Example of Technical University

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Abstract

This article describes pedagogical conditions of ensuring students readiness for scientific researches on the basis of scientific literature and experience of Penza State Technological University students. Introduction of suggested conditions favors the process of training of highly skilled expert who is ready for generation of new ideas in fields of science and engineering, their implementation in scientific and innovative projects; for conduction of scientific researches and testing of their results.

Keywords: scientific research, professional competences, pedagogical conditions

1. Introduction

Globalization in European countries and in America launched a persistent work at the problem of organization of shared education which will give a student an opportunity to have an internship in any university of the world, to get knowledge and skills at open courses system (MOOCs), to perform joint researches and projects (Marginson, 2011, 2014; De Wit, 2013; Kirwan, 2010; Gershuny, 2011; Atkinson & Audretsch, 2010; Salmi, 2009). That is why a critical goal of education is training of highly skilled competent professionals for solving global problems. In order to achieve this goal it is necessary to develop identical educational programs which will be aimed at effective attainment of final goals, stated according to competences. This is confirmed by the project called TUNING ("Tuning of Educational Structures in Europe"), which helped to form the following hierarchy of competences:

(1) General (universal) competences important for particular social groups (for example graduates, employers, teachers):

- Instrumental;
- Interpersonal;
- Systemic.

(2) Specific (professional) competences relevant to subject field (academic, subject oriented competences) which provide peculiarity and independence of particular educational programs for a degree:

- General professional – basic theoretical professional knowledge, basic practical professional skills;
- Profession-oriented – defined by educational institution according to order for professional training (Tuning, 2001).

In Russia this competence groups are represented in Federal State Educational Programs of Higher Education (FSEP HE), though they are not always evident. These standards assume big innovative opportunities which apply Russian and European educational experiences at professionals training (Slessarev et al., 2014). FSEP HE single out students professional competences at scientific research (SR). It emphasizes urgency and importance of work aimed at formation of competences that provide readiness to stated activity (Sergeeva & Vagaeva, 2011).

2. Methodology

We have conducted a research of ensuring student's readiness to SR. The research was conducted in Penza State Technological University. According to the findings we are able to make a conclusion about establishing of pedagogical conditions that provide efficiency of this process (Lyushev et al., 2014).

“Condition” category is treated as a superordinate one to subordinate concepts of “environment”, “circumstances”, “surroundings” in psychological and pedagogical literature, thus we broaden the range of objects necessary for initiation, existence and alternation of pedagogical system. N.M. Borytko defines pedagogical conditions as an external factor, influencing the pedagogical process which was deliberately created by teacher and assumes achievement of the result (Borytko et al., 2009, p. 54).

N. M. Jakovleva underlines integrated nature of pedagogical conditions and regards them as a set of educational process measures which help students to reach professional and creative level of activity (Jakovleva, 1992, p. 154).

This category is treated from pedagogical point of view in works of V.I. Andreev who regards condition as goal-oriented selection, designing and application of content elements, education methods and training for didactic aims (Andreev, 1996).

We treat pedagogical conditions as a sum-total of inner and outer circumstances of educational process, realization of which influences the process of effective formation of student’s readiness to research activity (Plakhina et al., 2011).

Proceed to the description of pedagogical conditions defined by the research.

2.1 Motivational

2.1.1 Accurate Procedures of Students’ Scientific Research Encouragement

Maintaining and development of high school scientific potential requires resolution of issues of students’ scientific research (SSR) encouragement. In higher educational institutions efficient involvement of students, teachers, scientists and other officials into scientific research is based on encouragement in particular.

We agree with Balashov who divides SSR encouragement into material, social and moral (Balashov et al., 2002; Kukushkina, 2011). Material encouragement favors development and efficiency increase of SSR based on objective interest in material support of all participants. Material encouragement includes monetary and nonmonetary encouragement. Basic types of monetary encouragement of students are:

- Selective scholarships—enhanced scholarships, nominal scholarships, scholarships from President of Russian Federation for students, studying in Russia and abroad, scholarships from Russian Government;
- Increments to scholarships;
- Grants for SR, projects realization and studying abroad;
- Cash bonuses;
- Souvenirs and valuable presents.
- Basic types of nonmonetary encouragement:
- Payment of business trips and organizational fees for participation in scientific events;
- Payment of traineeships and studying (Balashov et al., 2002, p. 122).

Social encouragement is based at application of social procedure and includes social support of SSR system participants. Primary measure of social support of students is issuance of subsidized vouchers for rest and treatment.

Moral encouragement of SSR participants is a form of involvement and increase of efficiency of all SSR participants, based on public recognition of their scientific achievements and prestige rise. Main types of moral encouragement are official praise; awarding; assigning of honorary titles; publishing of scientific findings; SSR findings layout on websites; information boards of higher education institutions, faculties, departments, student scientific society (Balashov et al., 2002, p. 127). Besides the named types all SSR participants are subjected to stimulating influence of publicity—broad announcement of SSR and its findings, ceremonial presentation of awards and stimulations by media.

Major types of student encouragement in Penza State Technological University (PenzSTU) for achievements in SSR are accepting scientific findings to the account of essays, laboratory works, term papers, projects, credits and exams in corresponding subjects; opportunity to have individual schedule of studying (a shorter one as well); opportunity to take credits and exams before the appointed time. Such encouragement measures help to involve students to research activity from their first days at higher educational institution.

Students of PenzSTU who achieved significant results in SSR and study on a commercial basis receive an opportunity to have benefits in payments or to transfer to a state-financed place.

Students who have achievements in SSR get increments to scholarships every term. These students are chosen by scientific achievement portfolio contest. After this contest the best students get increment to state scholarship for the next term and receive diploma for achieved results.

Moreover the most distinguished students of PenzSTU are chosen at the end of every term and they get a one-time bonus. There is a contest “Student Olympus” and one of its aims is to choose the best student who achieved the most significant results in SRA.

Students of PenzSTU having the best results in scientific and educational activity are recommended for scholarships from President, Government of Russian Federation, Governor of Penza region, Head of administration of Penza city and other scholarships established by different funds.

Prize-winners of institutional, regional, Russian and international scientific events receive bonuses and are awarded by diplomas, souvenirs and valuable presents with PenzSTU logos.

Grant contest “Science–step to the future” is held in PenzSTU every year. In the result of this contest students can receive a support for scientific research and realization of project.

Organizational and material assistance for start of small innovative business is a respectively new form of encouragement of PenzSTU students participating in SSR. According to the order of PenzSTU chancellor there are consultations for students on issues of starting and registration of small innovative businesses, keeping of accounting and tax records, application of results of intellectual activity, participation in grants and contests for innovative companies. All costs for beginning a business are refunded by the university.

Moreover, the most important measures of encouragements of PenzSTU students, participating in research activity are:

- Department and university recommendations for job, magistracy and postgraduate course;
- Introduction of the best students’ works for participation in scientific contests, exhibitions, forums of different levels;
- Nomination for grants of scientific and other funds, enterprises and organizations;
- Payment for students business trips for participation in regional, Russian and international events;
- Payment for students publications;
- Payment for applications for patents and certificates;
- Sightseeing programs;
- Subsidized vouchers for rest;
- Assignment for training in major Russian and foreign universities and scientific centers.

Thus in a present-day advancing higher educational institution it is necessary to establish a system of material, social and moral assistance to students participating in scientific research.

2.1.2 Involvement of Students to Scientific Works at Departments for Salary

This condition is the most important one for settling teamwork of students and research advisors. Collaborative researches with teachers give students opportunity to master tricks and methods of conduction scientific researches and to gain skills of individual creative work. Students of 2-5 years of studying usually take part in this type of work. They start with searching and analysis of publications concerning the subject of research and then they do patent researches, prepare laboratory samples and conduct joint testing. As a result of such approach to SSR students acquire abilities necessary for individual scientific researches.

PenzSTU involves students to SSR at the departments within grants of Federal special purpose program “Researches and developments in priority areas of science and technology sector of Russia in 2014-2015”, grants of Russian Fund of Fundamental Researches, Russian Humanitarian Scientific Fund, and as a part of economic and contractual works with enterprises. Students are involved in work of temporary constructive teams and get salaries. In the result of these work students and their research advisors have publications in media, patents and certificates for intellectual property and other results of scientific activity.

2.2 Didactic

2.2.1 Interrelation of Curricular, Curricular Research and Extra-Curricular Research Activities

Curriculums of all departments include conduction of scientific researches by students. They can be fulfilled as a part of curricular, curricular research and extra-curricular research activity.

SR should be interrelated with educational activity in order to form creative competences of students of technical universities. Curricular activity is full of creative and research tasks for a deeper understanding of theoretical material; curricular research activity is a check-up of theoretical material that students get on practice by writing essays and term papers; extra-curricular SSR in its turn is organized on the basis of knowledge that students get at curriculum classes and is aimed at a deeper studying of particular aspects by conduction of scientific researches and sometimes by acquiring new knowledge in practical scientific activity.

There is a course “Scientific research of technical university student” for students of PenzSTU, that is a connecting-link between curricular, curricular research and extra-curricular SSR. Students apply theoretical and research knowledge and use active and interactive methods of studying in this course. Experts of the subject visit many classes of extra-curricular course and make them practice-oriented.

2.2.2 Informational, Material, Technical and Administrative Assistance to Students for Participation in Scientific Researches

About two hundred years ago N.M. Rothschild said “The one, who owns information, owns the world”. This phrase is a motto of many people who achieved success in their professional activity. However according to the opinion of Penza State Technological University chancellor V.B. Moissejev communication or accurate transmission of information is also very important. Communication between participants of educational process and the transmission of knowledge and experience from scientists to students above all, is a key aspect of education and science.

That is why the primary attention should be paid to informational assistance concerning different scientific events; material and technical assistance including refund of costs on participation in scientific events, searching of equipment for designing and production of laboratory samples, searching of devices for required measurements and researches, access to necessary library funds; administrative assistance concerning filling the required papers, cooperation with chiefs of scientific and innovative departments of the university, interaction with outside companies (higher educational institutions, enterprises, business incubators, industrial parks).

News about different scientific events for students is posted at the home page of PenzSTU website. Besides PenzSTU website has a section called “Scientific research of students” where there is information about contests of different levels and there are examples of applications for participation in the contests. Moreover there is an educational portal MOODLE (Module Object Oriented Dynamic Learning Environment), where you can find books necessary for scientific research. This educational portal provides opportunity for communication between students and research advisors. Regarding the fact that present-day youth spends much time in social networks, there was created a group in social network “Vkontakte” for students conducting scientific and project activity. Every interested student, post-graduate, scientist, teacher can join this group and get information about scientific contests, exchange ideas, discuss scientific problems.

2.3 *Communicatory*

2.3.1 Organization of Continuous Communication between Students and Science Researchers

Joint activity and communication between scientist and students during one particular research favors individualization of educational process. Besides, creative cooperation of a teacher and a student stimulates natural influence of teacher’s personality on personality formation of the future expert (Razuvaev, 2012).

Professional and teaching staff of PenzSTU has high creative potential and is able to efficiently solve problems of human resource development according to needs and requirements of personality and social and economic sphere of the region. PenzSTU is in the first division of Russian universities in the aspect of quality of graduates in fields of IT, mechanical engineering and economy.

There is much attention paid to organization of interaction between students and science researchers in PenzSTU from the first days of their studying in the university. For that purpose there is a wide range of events for students, one of which is “Meeting science”. For this event every department of PenzSTU organizes and conducts: presentation of scientific fields of the department; introduction to scientists of the department – potential or real scientific advisors of students; presentation of existing scientific projects, in which students can take part. Another event is annual scientific conference of the university students, post-graduates and young scientists “Urgent problems of science and education”. This conference involves all scientific fields of PenzSTU and includes more than 20 sections. This conference has one interesting feature: scientific advisors of underclassmen (students of 1-2 years) are post-graduates, young scientists and the best senior students. The latter already have scientific advisors and introduce underclassmen to them (Korchagina, 2013). Thus intergenerational continuity takes place in PenzSTU and scientific groups effectively solving scientific tasks are created.

2.3.2 Arrangement and Holding of Public Scientific Events in Higher Educational Institution

Public scientific events of the university are of great importance for students training for SR.

It is necessary to underline the following events of PenzSTU: scientific conference of the university students, post-graduates and young scientists “Urgent problems of science and education”; “IQ-sprint” contest; open contest of university students’ scientific works in natural, technical and humanitarian sciences; contest of research and investment projects of students and post-graduates.

These events have competitive element and function as: an opportunity to provide students with an experience of participation in scientific events; a way to practice basic methods of defense of scientific position, of discussions, of project presentation; a qualifying contest of projects for the contests of higher level; a way to attach youth to the fields of science and innovations.

2.4 *Infrastructural*

2.4.1 Objects of Scientific and Innovative Infrastructure in the University

A system of organizational and innovative structures for scientific activities in the university plays an important role in the process of training students for SR.

We treat scientific and innovative infrastructure of the university as a complex of interrelated structures, providing implementation of scientific and innovative activity. Scientific and innovative infrastructure of the university includes: industrial parks, innovative centers, scientific centers and divisions, small innovative enterprises, etc.

Purpose of these structures is not only to concentrate labor, material, financial and other resources, increase of science influence in solving educational tasks, maintaining and consolidation of basic, defining character of science for the development of higher education, involvement of young researches (students of schools, lyceums, secondary schools, universities and post graduate students) to scientific activity, but also arrangement of required conditions for improvement of educational background of competitive experts.

Pro-rector for Research manages the organization of student’s scientific researches in PenzSTU. Assistant Deans for Research are responsible for SSR on faculty level and Assistant Managers for Research regulate SSR in departments.

Scientific and innovative subdivisions carry out SSR in PenzSTU. They train experts, scientific, scientific and research personnel according to international requirements; they fulfill competent approach in educational system, and implement the concept of creative activity; they unite scientific and educational processes; they reproduce and increase intellectual resources of the university, train talented students for teaching and scientific activity and attach them to PenzSTU in order to maintain continuity of scientific and teaching schools.

2.4.2 Independent Project-Oriented Student Microenvironment

In order to meet this condition the university should have student scientific division which has its mission and organizational structure. These divisions usually are student scientific societies, youth centers, design departments.

Major purpose of such divisions is development of skills of individual scientific work, individual scientific search and decision of practical tasks, deep studying of different scientific and technological fields and project implementation as well. Members of such structural divisions are usually students of different specialties and scientific fields, students of different years, post graduates and young scientists. Students get a unique opportunity to conduct interdisciplinary researches and projects. Interrelation of students who take active part in scientific research unites people of the same ideas and creates a positive image of student science.

Student Scientific and Project Campus is this structural unit in PenzSTU.

Campus goal is preparation, advance and fulfillment of scientific and innovative projects of students, post-graduates and young scientists of the university.

Campus has modern PC, access to the Internet, presentation screen, and round table for conferences, meetings and negotiations. Campus has six subdivisions: new methods and technology, food engineering, economics and business, biomedtechnology, bioengineering, ecology, IT and design, pedagogy and psychology. Each subdivision has its head from among students, post-graduates and young scientists. Students can take part in work of any subdivision and to fulfill interdisciplinary projects.

Ideas in Campus are constantly generated and discussed, project teams are created and projects are arranged.

For Russia Campus is a relatively new approach to the organization of student scientific microenvironment that include real and virtual (specially created Internet resource) arena for student interaction. Such approach to student communication favors:

- Setting of purpose of self-education;
- Improvement of student intellectual initiative, creative approach to one's activity;
- Advance of systemic thinking and thus forecasting abilities;
- Rise of knowledge prestige, of competence in different fields, of general culture of students;
- Acquisition of experience of speaking in public and participation in debates;
- Establishment of subject communication among students, broadening of students social contacts;
- Establishment of conditions for personification of studying room;
- Strengthening of social partnership with enterprises that ask for trained personnel.

2.5 Technological

2.5.1 Resource Support of Scientific Researches

We regard resource support required for conduction of researches as a free access to scientific industrial and informational resources: equipment and machines for production of prototypes and samples, supervisory instruments, library stocks. If the university does not have required equipment it is possible to become partners with enterprises, regional business incubators and industrial parks, in this case students will get an opportunity to conduct their researches on modern high-tech equipment.

Informational resources are of great importance for conduction of researches. Informational support of scientific researches in the university means the availability of modern informational technologies, free access to any required scientific data by means of Internet and conventional sources.

PenzSTU has: studying and engineering center "Technologies of mechanical engineering", where there are modern machines with programmed numerical control for production of parts and 3D printers for computer design and prototyping; studying and scientific center of multi-access to equipment and experimental facilities "Biotechnologies and technospheric security", where there are modern microscopes and other equipment required for conduction of researches and experiments in the field of biotechnologies. Students can use these centers not only for conduction of scientific researches but also for carrying out laboratory and practical works for university subjects and practice.

The university has contracts with industrial park "Yablochkov", industrial park of high tech, Penza Regional Union of Business Incubators about the opportunity to use equipment for the conduction of scientific researches and fulfillment of projects. It provides better access to modern high tech equipment concentrated in laboratories and centers of industrial parks and business incubators of Penza region.

For example industrial park "Yablochkov" has the following laboratories:

(1) IT Division:

- Laboratory for digital signal devices processing is aimed for development of embedded software of microprocessors for processing digital signal of different classes;
- Laboratory of signal analysis is aimed at development and adjustment of electronic devices for analysis of reports for main and newly developed standards of digital data transfer by telecommunication paths. It has devices which can catch and analyze reports SATA, SAS, PCI-Express which are widely spread in computing systems;
- Monitoring laboratory of power-efficiency of housing and communal services and budgetary objects is oriented for development and creation of new models of communication devices (controllers) for communal services objects, development of program-technical complex of dispatching (monitoring) of power consumption from distributed objects of communal services control;
- Laboratory of circuit and solid state design is oriented for automation of designing and testing for exposure of operation factors of mechanic and electro mechanic components CEA, including microsystem technology items;

(2) Instrument Engineering Division:

- Prototyping laboratory is oriented for production of parts and subunits by prototyping method and molding

of chemically solidificated polyurethanes to silicone forms, control of sizes of complex construction details and creation of 3D-models from existing samples, production of photomasks of prototypes of 5 print class and over, testing of CEA for satisfying the requirements of vibration strength and vibration resistance;

- Laboratory of testing, electromagnetic compatibility, control instrumentation – laboratory testing of installation quality of circuit boards, control and testing of developed and produced experimental models of CEA for satisfaction of requirements for resistance to salt, sea fog, high (low) temperature, measurement of electromagnetic radiation of CEA, electromagnetic compatibility of radioelectronic devices;
- Laboratory of surface mounting gives opportunity to do mounting of board assemblies (boards) at modern highly productive equipment for small innovative enterprises of the region. Laboratory is also used for mastering skills of surface mounting by beginning businessmen;

(3) Materials Science Division:

- Laboratory of mechanical testing and mechanical area are aimed for durability test operation of new materials (metals) by deformation, rupture of welding surfaces. Program-operated vertical five-axis machine is made for integrated processing of parts;
- Laboratory of nondestructive control methods is oriented for conduction of researches and nondestructive quality control of materials, welding junction, machinery parts, pieces of technological equipment by ways of visual and measuring magneto-powder control, ultrasonic, radiographic and whirlwind defectoscopy.

An opportunity to use modern high tech equipment and devices for conduction researches and implementation of projects is the most important condition of applied science progress in technical university.

Informational resources also play important role in research conduction. Informational support of university scientific researches assumes availability of modern information technologies, free access to all required Russian as well as foreign information, by means of Internet and conventional sources.

In PenzSTU informational support is provided by library. It stocks about 300 000 pieces. This fund is almost universal. The main attention is paid to acquisition, fund integrity and the whole new level of library and informational service for readers based on automation of technological processes.

In the result of automation of library and bibliographic processes there was created an electronic catalog, it is posted on university website and is very popular among students and teachers of the university. E-catalogue has 37000 items and is constantly renewed.

Experience has proven that application of new information technologies favors the increase of SSR quality by ensuring an access to informational and educational resources thus directly influencing the level of students' readiness for SR.

2.5.2 Student Involvement in Scientific and Production Activity in the University

Modern educational process of the university includes continuous participation of students in scientific and practical activity and mainly in production activity of the enterprise. Constant participation of students in practical activity of industrial enterprises could end up in students' failure to learn basic educational program because of lack of time. Besides thus scientific aspect of educational process is lost. That is why it is better to involve students in scientific and production activity of small innovative enterprises of the university, engineering and IT centers, business incubators.

Students of PenzSTU together with university post graduates and scientists take part in implementation of projects. This activity includes: computer design of parts, prototyping, development of laboratory and experimental samples and testing. Such approach to organization of scientific and practical activity gives students an opportunity to acquire knowledge and skills of production, to take part in scientific researches and to study at the same time.

3. Results and Discussion

Application of introduced pedagogical conditions in Penza State Technological University favored student involvement in scientific and research activity from the first year of studying. This fact proves the hypothesis of the conducted research. The described pedagogical conditions could be used for formation and development of professional competences of students. Results that students have achieved are described in details in previous research (Lyushev et al., 2014).

Further in the research we intend to introduce these pedagogical conditions in branches of Penza State Technological University (Zarechnyi Technological Institute, Kamenka Technological Institute) and in

institutions of secondary professional education and to analyze alterations in students' professional competences shaping.

4. Conclusion

In nowadays labor market society and employers are interested in university graduates whose aim is to find new unique solutions of professional tasks, which have a complete creative line of thought and possess professional competences of high level (Bakharev & Gordeev, 2011; Korostelev, 2011).

Professional training of students includes scientific research that is a basis and a major factor of students' professional readiness, favorable environment for their professional and creative self-fulfillment.

Besides, the analysis of educational normative documents and results of university practical activity prove that SR stimulates shaping and development of professional competences, and the level of their completeness defines students' readiness to SR (Vostroknutov, 2013).

Thus an important aspect of educational system is a creation of pedagogical conditions that provide efficient training of students for scientific research from the first year of studying.

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