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Provision of the Quality of Engineering Education in the Studies of Mathematics at the University

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***Abstract* – Problems of the study process of mathematics at the modern university, aim of which is to prepare educated and competent specialists, so that they are eligible to the changes in our society that are caused by the globalization of economics and information, are mentioned in this article. Goals of the universities are becoming broader and more varied: they provide not only competent specialists, that have acquainted narrow range of knowledge in some specialty, but also create equal opportunities for extensive range of residents to get education, to gain new knowledge in high quality research and to promote the development of the national economy. Goals of mathematics are firstly determined by the fact that students must be prepared to use in practice the acquired subject in real life. The quality of the learnable competences depends not only on the amount of gained knowledge in mathematics, but mainly on the acquisition level of problem-solving abilities. It is important to update two main principles of study in the organization of the study process: implementation of the interdisciplinary approach and student's self-directed studies. While transferring to the self-directed studies, changes in the scholastic content, diversity of the applicable methods and in the system of evaluation must be made in the study process of universities. The role of a pedagogue must be appraised. Every teacher must create the new didactic system in educating specialists in a very deliberative manner, students' motivation and independent work must be promoted with varied methods to raise the level of competence in the future specialists.**

***Keywords* – self-directed studies, engineering education, competencies**

I. Introduction

Determinative of the competitiveness of the country is an educated, competent person, who, as a proficient user of the information, becomes the main factor of economic growth. Any specialist nowadays undergoes those rapid changes that are connected with globalization of economics and information; namely, there are 3 directions of changes [2, 7]:

- Globalization, firstly economical, and internationalization of the education that is connected with that.
- Rapid development of the information technologies and their penetration into all areas of life.
- Development of the science and technology and the increase of their role in different fields of life.

Higher education is an important tool for implementation of lifelong learning and training for qualification. Common, coordinated and understandable qualification system must be developed in Europe, where the degree of education, levels of knowledge and skills are variable according to the needs of the labour market and academic facilities. In the recent years, Latvia takes one of the first places among European countries in accordance with the number of students per all inhabitants. Unfortunately, a large number of students is not an indicator for high quality of education. One of the main problems in Latvia is the lack of students in natural sciences and engineering – more than a half of students study social sciences, and only 13% from the funded places at university are in the natural science and engineering. Acquisition of the engineering profession is impeded by insufficient and not well-timed acquirement of skills and knowledge in mathematics and natural science in programs of general an professional secondary education [1]. Economical crisis of the recent years threatens to worsen the situation even more. The quality of the higher education is formed by the quality of separate subjects of the study programs. Expediency and the necessary number of the subjects within the study programs are evaluated by the input that the corresponding subject gives to reach the total goals of the studies.

Nowadays education system must provide an opportunity to everyone to get and enhance their competences – to obtain education, train for a new occupation, to perfect one's knowledge during all life in accordance with the needs of society and personality, thereby, giving a chance to successfully incorporate in social, economical, political and life processes [8].

Since natural sciences (mathematics, physics, and chemistry) are a base for engineering, then studies of mathematics are in all programs of higher academic and professional education. Nowadays, aims of teaching mathematics state that students must be prepared to apply the acquired subject practically in life, as well as students must acquire theoretical basic principles, because they will be needed to understand professional literature and use it creatively. That is why improvement of the program of mathematics is based on two categories: mathematics as a base for other subjects and as a tool for solving problems of the world.

There are three important factors that influence the education of mathematics in Latvia, coefficient – demand for highly qualified engineers, and disincentive – constant content of the study program, as well as the reduced time for mathematical studies. Since some students have insufficient basic knowledge in mathematics and capability of cognition, they are not able to achieve good results during the studies, and that is why often the interest in natural sciences is lost.

Unfortunately, because of bad results, a student is expelled from a university. Taking it into consideration, universities should develop more resilient and attractive study programs of mathematics, to be able to improve students' low level of knowledge.

The management of the education process of mathematics can be viewed in two aspects:

1) creation of study program of mathematics – establishing the content, amount and competencies to be learnt;
2) organization of the study process.

Several inner factors influence the study process of mathematics at universities:

1) disparity between both level of knowledge, and level of the learning skills among student;
2) heterogeneous structure of the age of the students, especially in part-time and Master study programs;
3) different styles of learning;
4) lack of motivation in students who are not interested in the study process and in the acquisition of knowledge;
5) large groups of students that limits the diversification of the teaching methods;
6) a limited number of lectures in natural sciences at technical universities, etc.

The above-mentioned circumstances define the necessity of choosing effective teaching methods and resources in the study process of mathematics in order to implement the goals and tasks defined in the study program, and to achieve wholeness of the study process.

II. Review of the Problem

According to I. Žogla [9], quality of the higher education nowadays means, firstly, a change of paradigm and selection of suitable didactic models for it. She also states that for a university it means not teaching students, but allowing them to learn. Learning is not just acquisition of theory and concepts, but also acquisition of social skills and values, as well as creation of attitude and others. New ideas constantly appear in pedagogy, engrossing methods are offered, but, as I. Žogla [10] stresses, pedagogical cognitions in East and West are grounded on different conceptual approaches that sometimes differ even in a range of one country.

Didactic model is defined by the paradigm and theory whose model is based upon: theory of cognitive, emotional, moral and physical development, socialization, theory of personality's action, and others [11].

To ensure the integrity of the study process at the university, a lecturer must comply with 3 factors during the process of the acquisition of all subjects:

Factor 1. Each lecturer must perform a bilateral task – create effective teaching methods for the subject and be aware of the limits that are incorporated in specific features of each subject.

Some special characteristics of mathematics can be stated in the context with intermediary disciplinary approach and its teaching.

1. Mathematics is a sign language, which includes uninterrupted unity between natural language and special language of symbols, with precise rules in the education of words.

During the process of acquisition of new material, a student and lecturer work on gaining several different skills:

a) skills to use formal rules precisely, sometimes rather abstract, complicated and multistage;

b) skills to choose from the long list of familiar sentences the one that is necessary to complete the task;

c) skills to form sequence of applicable rules to solve the tasks.

2. Long chains of logical conclusions are characteristic to mathematics.

3. Enormously large didactic units for the acquisition of the material are characteristic of teaching mathematics.

It should be stressed that a lecturer cannot avoid dealing with complicated definitions, as well as developing great proofs. It is impossible to prepare an effective researcher without the knowledge of these subjects.

4. Many problem situations that have appeared during the acquisition of the system of the mathematical knowledge allow small possibility for students' discussions.

If a student has not come across the necessity to do chains of long logical conclusions before commencing the studies at a university, if he or she is not physically or mentally ready for hard work to be able to quickly acquire great units of information (characteristics 2, 3), then tuition of mathematics at a university will be quite troublesome, sometimes even impossible. There is a reason why V. A. Kruteckij thinks that "lowered tiredness in the process of acquiring mathematics" is one of student's components of mathematical skills [13].

Acquisition of mathematics consumes a lot of time and energy to develop complete technical skills and abilities. Of course, knowledge of formal mathematical formulas and identical modifications do not form the essence of mathematics, without knowing a great deal of formulas and without free management of identical modifications, acquisition of mathematics is cannot be considered, not to mention the creativity in mathematics., not to mention, creativity in the mathematics field. Thus, a student, who studies mathematics, works on personal border of intellectual abilities and under conditions of lack of time. He or she acquires material, the main characteristics of which, is its logical structure.

In some literature sources [6] *cognitive flexibility principle* is separately isolated. By cognitive flexibility Jacobson and Spiro understand the ability to spontaneously reconstruct knowledge and use it radically in specific situations. That is why knowledge must be obtained in as many various contexts as possible to strengthen in several conceptual dimensions. While creating learning environment, simplifications must be avoided; on the contrary – content of studies must be created complex and adjustable to real situations. To enable it, Jacobson and Spiro suggest the following principles:

- a teacher must offer a diverse content of studies;
- learning materials must be designed in a way that avoids simplification and so that they enable the acquisition of knowledge that depends on the context dependant knowledge acquisition;

- classes must be built on separate situations and must outline the construction of knowledge.

Course books and other sources must be to the utmost correlated.

The main idea of the pedagogical constructionism is the following: knowledge cannot be handed over to a student in a finished form. Teacher's function is only an attempt to change the learning environment, so that student could create such cognitive structures, which a teacher wants to hand over. Constructionist approach that P. Lorence stated (classics of mathematical constructionism) is characterized by the following idea: "We only then understand something, when we can create it ourselves" [12].

As Gage and Berliner mark [4], in the field of solving clearly defined problems, the main importance may turn out to be mentality, persistence and experience of life. This kind of task solving can be acquired by almost anyone, but there are fewer people who learn solving more complex problems that cannot be precisely defined. Imprecisely defined problems often do not have indications of what exactly must be proven (a solver must put forward a hypothesis himself) or if anything must be proven at all. That is why to solve these problems, broad knowledge, especially procedural, and experience is necessary. Experienced problem solvers work after schemes, abstract reproduction of apparitions. Ability to identify what knowledge to use in a concrete situation and continuing to use them in future authors call as ability to perform knowledge transfer. Transfer occurs if two tasks have similar elements, and a solver notices this similarity. Thus, it is important to mark out the similarity of two problems for transfer to happen.

Improvements of the study program of mathematics include the evaluation of the size of the existing program, content and learnable competences according to the potentialities of the modern technologies.

That is why study programs of mathematics and didactics must be improved by improving on IT (paying more attention to the use of mathematics, int. al, using IT), creating course material based on modern technologies and providing the access to the Internet.

By including online learning technologies into higher education, we must be ready to accept new learning modules and methods that embrace multidimensional forms of learning models and methods that are supported by the newest technological solutions.

Factor 2. Each student must be given a chance to acquire those traits that are characteristic to the specialist of the corresponding profession. Since 2 sciences – psychology and information science – explore the processes of the production, processing and conservation of the information, a lecturer must take into account the newest statements and recommendations of these sciences when determining the course tasks:

1. Any preparation system of the specialist at university is aimed at achieving one goal – to prepare a competent specialist for current time.

2. To prepare specialists in a form of competency means giving them such tuition that they are capable to solve any current professional problems at work.

To consider a specialist to be competent, he or she must acquire following 2 requirements during the study process:

1. Must acquire definite number of competencies.

2. Must be able to solve problems of diverse levels of complicity that are put forward by the society in a corresponding field.

Thus it must be stressed that, with respect to the subject, a prospective specialist solves all problems using one technology:

1. Problem is formulated in a cognitive sphere. The more complicated the problem is, the higher ability to formulate it is asked from a student (abilities of type 1).

2. Solution to the problem is being proposed. The more complicated the problem is, the higher developed construction abilities a student must have (abilities of type 2).

3. Constructive solution to the problem is carried out in real life. The more complicated the problem is, the higher abilities of implementation are asked from a student (abilities of type 3).

Consequently, the quality of student's competencies depends not only on the amount of obtained knowledge, but, mostly, on the acquisition level of these 3 abilities and knowledge are considered as a supplementary aid together with the abilities of problem solving.

Five parameters must be taken into consideration when evaluating the competencies of the prospective engineer – amount of knowledge, integrity and three abilities of the problem solving.

Factor 3. Lecturer must take into account the dual character of the learning process at a university – interaction of an individual and collective action. V. A. Lektorskij [14] writes that every individual, his or her cognition and cogitation processes can be understood only in relation to various practical collective and cognition forms. In turn, collective subject acts not only through inner structures of the cognition of the individual, but through outer subject-practical action and collectively Gnostic action in the system of objective knowledge.

There are 3 subjects in the pedagogical process at a university – a student, an academic group and a lecturer, who is an organizer of the cognitive action. Each lecturer represents himself/ herself in 2 positions – both as a representative of a particular science, from whom student gets the necessary information within the framework of the subject and acquirements for the research paper and in a wider sense as a representative of a particular profession, a specialist.

If a lecturer is a mediatory between the group of students and the system of the knowledge of the subject, and a regulator of this acquisition, he or she is called a moderator. Lecturer-moderator must consider structuring the main competences in students, emphasizing main aspects of teaching that are common to many disciplines, and those disciplines are – creation of students' motivation, using

methods that raise the activity and development of the communication skills in a joined Gnostic action.

The approach to the organization of the study process changes, updating two main learning principles – intermediary discipline approach and self-driven studies.

Interdisciplinary approach or cross-curricular link is the application of knowledge and skills acquired within one subject in the acquisition of another subject. The cross-curricular link is based on the subject components that are common in different subjects [3].

It is not so easy to implement the interdisciplinary approach within the study process as the cusp of allied subjects must be recognized and their coordination within educational programmes must be performed. It requires teamwork of all university lecturers involved because every lecturer is more competent in his/her subject.

The professional aspect of the cross-curricular link is related to the orientation of students to apply the theoretical knowledge of subjects of general education in solving tasks of practical mathematics, to improve, store and systemize independently particular facts, technical and technological information, practical approaches and theoretical knowledge in order to get more thorough notion of the chosen profession.

At the university within the studies of mathematics, the following ways of solution can be accepted to improve the cross-curricular link:

Special methodological recommendations should be prepared for lecturers of mathematics about the link of mathematics with other acquired specialties at the university.

Study materials for lecturers of specific subjects should be developed where the principles of mathematics would be revealed.

Study materials should be developed where the content of practical works of cross-curricular character and conducting methodology would be discovered in every specialty.

Preparing the lecturers of mathematics for universities, a link among general course of mathematics, teaching methodology course and special courses of mathematics in professional education should be established considering the specialties acquirable in Latvia.

In order to increase students' sense of responsibility for the study process and to facilitate the ability to acquire knowledge and skills independently, it is important to formulate prerequisites at the university for self-directed studies. It means that students participate in the process of putting forward the study goals, plan the acquisition of the theme, and together with their piers or pedagogues agree upon the final evaluation of their work. Within this process the pedagogue only outlines "the steps of cognition".

Consequently, the self-directed studies are the students' active work and collaboration in the planning of the content of studies, acquisition of knowledge and skills, and evaluation of their results.

It demands a better understanding of the study process, results of the work, and skills of self-evaluation, determination, self-motivation, responsibility and self-direction. Students should be able to analyse their devotion to the work and to determine "the stumbling blocks" that delay the progress in studies.

It is advisable to turn to the self-directed studies gradually following these steps:

The process of self-direction can be discovered within individual tasks;

A common plan of action must be developed and the process of evaluation clarified;

To facilitate the process of students' independent thinking – skills to formulate their opinion, their own solutions to the problems are to be developed;

To teach them how to study scientific literature and acquire skills and abilities to process and organise the information [5].

III. Conclusions

1. Nowadays the objectives of teaching mathematics determine that students must be practically prepared to apply the acquired subject in the real life so that the study process must be monolithic, appropriately developed, and it should correspond to the demands advanced by the globalization of modern economy and informatics.
2. The course of mathematics at the universities must be developed and didactics improved based on ICT (paying greater attention to the application of mathematics including the usage of ICT), also creating the study material based on modern technologies and ensuring the access of the material on the Internet. When implementing the online studying technologies in the higher education, new models and methods of studying that include multidimensional forms of study objects and courses supported by the newest technological solutions should be accepted.
3. It should be considered that the quality of student's competence depends not only on the amount of knowledge acquired in mathematics, but mostly on the acquisition level of problem solving skills. Each student should be given the chance to acquire those qualities that are characteristic to the specialists of the respective profession.
4. It is important to update two main study principles in the organization of the study process: interdisciplinary approach and self-directed studies.
5. Modern studies are characterised by the change in attitude both from the lecturers, and students towards the content of studies, and the study process. It requires a flexible lecturer's approach to the organization of the study process and skills to combine the study methods effectively, as well as lecturer's Personal interest in the acquisition of mathematical skills of every student to help the young man to acquire many useful competences for life.

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Sarmīte Čerņajeva. Inženierzinātņu izglītības kvalitātes nodrošināšana matemātikas studijas universitātē
Rakstā minētas matemātikas studiju procesa problēmas mūsdienu augstskolā, kuras mērķis sagatavot izglītotus, kompetentus speciālistus, lai tie būtu piemēroti ekonomikas un informācijas globalizācijas radītajām pārmaiņām mūsu sabiedrībā. Augstskolu darbības mērķi paplašinās un kļūst daudzveidīgāki: tie paredz ne tikai sagatavot kompetentus speciālistus, kuri apguvuši šauru zināšanu apjomu kādā specialitātē, bet arī radīt vienlīdzīgas iespējas izglītības ieguvē plašam iedzīvotāju lokam, iegūt jaunas zināšanas augstas kvalitātes pētījumos, veicināt tautsaimniecības attīstību, citiem vārdiem sakot, studiju programmām jāsekmē intelektuālo, zinātnisko un tehnoloģisko principu apguve. Matemātikas mācīšanas mērķi, pirmkārt, nosaka tas, ka studentiem ir jābūt sagatavotiem praktiski izmantot apgūto mācību priekšmetu dzīvē. Apgūstamo kompetenču kvalitāte ir atkarīga ne tikai no iegūtā zināšanu apjoma matemātikā, bet galvenokārt no problēmu risināšanas spēju apguves līmeņa. Studiju procesa organizēšanā svarīgi aktualizēt divus galvenos mācību principus: starpdisciplīnu pieejas realizēšana un studentu pašvirzītās mācības. Pārejot uz pašvirzītām mācībām, augstskolas studiju procesā jāveic izmaiņas mācību saturā, pielietojamo metožu daudzveidībā, vērtēšanas sistēmā, jāizvērtē pedagoga loma. Tātad mūsdienu studijas raksturo attieksmju maiņa kā no docētāja, tā studenta puses gan pret studiju saturu, gan mācību procesu. Tas prasa pasniedzēja elastīgu pieeju studiju organizēšanai un efektīgu mācību metožu kombinēšanas prasmi, kā arī personisku ieinteresētību katra audzēkņa matemātisko prasmju apguvē. Tādējādi katram pasniedzējam ļoti pārdomāti jāveido jaunā didaktiskā sistēma speciālistu izglītošanā, daudzveidīgām metodēm jāveicina studentu motivācija un patstāvīgais darbs, lai celtu topošo speciālistu kompetenču līmeni.

Сармите Черняева. Обеспечение качества инженерного образования при изучении математики в университете
В статье рассматриваются проблемы организации учебного процесса в современном университете при обучении математики. Целью обучения является подготовка квалифицированных, компетентных специалистов, в условиях экономической и информационной глобализации. Учебные программы должны поддерживать как интеллектуальный, так и научно-технологический принципы обучения. Цели обучения математики, определяется тем, что студенты должны быть готовы использовать на практике приобретенные предметные знания в реальной жизни. Качество приобретенных компетенций зависит не только от количества приобретенных знаний в области математики, но главным образом, от умения применять знания в конкретной предметной области. Важно актуализировать два основных принципа обучения при организации учебного процесса: междисциплинарный подход и выработка навыков самостоятельного, целенаправленного обучения. Это требует внесения изменений в учебные планы университетского образования, в системы оценки знаний, в изменении роли преподавателя. Необходим гибкий подход преподавателя к организации учебного процесса, а также личная заинтересованность преподавателя в развитии математических способностей каждого студента. Таким образом, каждый преподаватель должен очень продуманно создавать новые дидактические системы в обучении специалистов, разнообразными методами вырабатывая у студентов мотивацию к самостоятельной работе, чтобы повысить уровень компетенции у будущих специалистов.