MATHEMATICS EDUCATION PROCESS IMPROVEMENT THROUGH COOPERATION: EXPERIENCE OF LATVIA UNIVERSITY OF AGRICULTURE

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Abstract: It is known that mobility, lifelong learning, use of the new technological tools and flexible approach to knowledge acquisition requires to search for new methods and to promote the studies program coherence in the European education area. Therefore the development of local and international cooperation in mathematics is topical issue for the Latvia University of Agriculture. To improve the teaching quality by means of exchanging teachers' experience, to learn about the problems and methods used to solve them in the neighbouring countries, during last three years two cooperation networks were developed: Cross-border network for adapting mathematical competences in the socio-economic development (Latvia University of Agriculture and Siauliai University) and Baltic network in agrometrics (Latvia University of Agriculture, Estonian University of Life Science and Aleksandras Stulginskis University). This article summarizes the past experience of the international cooperation in mathematics generalizing benefits, evaluates the progress achieved at Latvia University of Agriculture and impact on mathematics education development as well as outlines the future directions and possible forms of the cooperation.

Keywords: cooperation, mathematical competence, mathematics courses, teaching conception.

Introduction

Mathematics is a study subject that specialists of all sectors need as a base. That's why mathematics is being taught in schools, colleges, professional schools and universities. EU directives state that mathematics is one of 8 main competences that need to be developed in lifelong education. The "mathematical competence" is based on the ability to solve problems in everyday context, and places emphasis on aspects of the process and the habit of using models of thinking (logical and spatial) and presentation (formulas, constructs, graphs, charts, etc.). It consists in the ability to identify structures and connections, repetitions and systematic nature. Moreover, a positive attitude in mathematics is based on the respect of truth and willingness to look for reasons and that way assess their validity (Key competences…, 2006). Regardless there are several problems and considerations that influence the development of those competences of mathematics that is demanded by the labour market and rapid changes in social, technological, educational and other environments.

The most pressing problem is the low motivation of students to study mathematics. Both a few education researches and experience shows that the level of students' preparedness and knowledge is getting lower. This is leading to low students' motivation to achieve good study results. And that is leading to lower mathematics study quality. One must acknowledge that universities use traditional teaching/study methods that are not sufficient to fulfil requirements of labour market and requirements of society, developing competences of mathematics that is needed for new technology age. Lecturer–oriented lectures with clear and definite content and static information is not an effective way of carrying knowledge any longer. Mathematics is often represented as a long succession of facts to be memorised and reproduced. Moreover, the results of several researches show that mathematics that is taught in universities is not related to its usage in practical life situations. Several documents that analyse socio-economic development in local and regional level show that there is a lack of sufficient transfer of knowledge and technology to enterprises (Balciunas, Macaitiene, 2011).

Conditions mentioned before ask for an innovative study process that promotes organized and systematic education making mathematics more practically usable and giving knowledge that could be used easily in the labour market. The solution – different cooperation networks, new initiatives and education products that create new knowledge and methods of mathematics in study programs that contribute to solving problems mentioned before. In accordance with Bologna documents, it is important to improve the mobility of students and teaching staff as well as strengthen the competition

of the European universities in global education market, to promote the European co-operation in higher education, particularly with regards to curricular development, mobility schemes and integrated programs of study, training and research as well as exchange of experience between institutions and countries (Bologna Declaration, 1999). This poses new challenges for mathematics and the studies of its use and outlines the directions for future development in Latvia University of Agriculture (LUA). Therefore in 2009 the Cross-border network for adapting mathematical competences in the socio-economic development was developed in the framework of Latvian-Lithuanian cross-border cooperation program‘s project MATNET creating innovative educational products, new initiatives and strategies. The project’s members are Latvia University of Agriculture and Siauliai University (SU).

Cooperation among the Nordic and Baltic countries in agrometrics (mathematics and statistics in higher agricultural education and in the agriculture sciences) has been going on since 1997 with a view to identify the kind of mathematical education needed, enhance the quality of learning through the exchange of lecturers' experience and review the use of learning methods and mathematical modelling techniques in agriculture. During 2007-2010 it faced such topical questions as its leadership and the financial issues and started to seek for new forms of cooperation. Therefore in 2011 Baltic network in agrometrics was developed in the framework of Nordic Council of Ministers’ program Nordplus with purpose to renewal the cooperation at least among the Baltic National Universities of Agriculture: Latvia University of Agriculture (LUA), Estonian University of Life Science (EMU) and Aleksandras Stulginskis University (ASU, Lithuania).

This article summarizes the past experience of the international cooperation in mathematics generalizing benefits, evaluates the progress achieved as well as outlines the future directions and possible forms of the cooperation.

Methodology

Research methodology used in this article is evaluation of the experience of international cooperation in mathematics in connection with the development of the mathematics study process at the LUA, taking into consideration the author’s reflection, experience and observations.

Cooperation can be implemented at different levels – international and local. Both kinds of the cooperation include the development of the networks, participation in several professional institutions and implementation of the joint projects. Latvian University of Agriculture in collaboration with the Siauliai University, Estonian University of Life Science and Aleksandras Stulginskis University has been developed two cooperation networks and have been implemented joint projects within these networks.

The main objective of the cooperation with SU was to contribute to socio-economic development in preparing high quality competitive specialists for the labour market in the field of mathematics; to proper conditions for border region specialists to develop mathematical skills; to prepare specialists who will be able to apply ICT and integrate mathematic competences for problem solving, data analysis; to raise awareness, competitiveness and qualification for users, beneficiaries and stakeholders as well as to improve the quality and enhance the accessibility of mathematical competencies across border by creating, testing and integrating innovative ICT based educational products.

The purpose of the cooperation with EMU and ASU was to promote a fuller understanding of the role of mathematics and statistics in the agriculture education and its relevance to labour market needs; to achieve common guidelines in agrometrics (mathematics and statistics); to improve the teaching quality by means of exchanging teachers’ experience, to learn about the problems and methods used to solve them in the neighbouring countries; to promote the role of mathematics and statistics in the life-long learning.

As seen, cooperation objectives include all three directions of the mathematics study process: the development of a program, mathematics study process organization and support activities. Thus summarizing the experience of these cooperation in mathematics and taking into consideration the author’s reflection, experience and observations, generalized benefits from cooperation, evaluated the

progress achieved in all three mathematics study process directions as well as outlined the future directions arising out of the current topical issues in mathematics education.

Results and discussion

Assessing the cooperation with SU, EMU and ASU and implemented activities directions several conclusions on cooperation level can be made:

- The cooperation can be implemented through cooperation with other universities and with professional institutions as well;
- The cooperation with universities can be implemented by universities profile or by the level (local, regional, European etc.);
- Both international and local cooperation can be implemented in the study programs directions or particular specialty (e.g., civil engineering etc.);
- At local level - the cooperation between participants of study process: academic staff (mathematics and other subjects teachers, heads of the study programs; deans etc.); labour market (employees, employers); other interested parties (e.g., adult learners, lifelong learning providers).

The main reason for the cooperation of course mathematics education development - at university level as well as in the context of lifelong learning (LLL) where the universities play an important role. Summarizing the attainments within the projects mentioned above, cooperation impact on study process can be generalized following the directions:

- Mathematics curriculum development (learning outcomes, content, volume, methods used);
- Study process organization (usage ICT in studies, methodical materials, measurement of learning outcomes, teaching methods etc.);
- Study support system (teachers training, space for exchange experience, accessibility of mathematical competencies, the motivation of the students, etc.).

Higher education is something more than just formal study programs and curricula. It includes preparation of school students to make them capable enter universities as well as further education of specialists during their careers. The cooperation forms as well as their impact on mathematics education process development generalized in Figure 1.

In order to improve mathematics education process several activities have been implemented during three years cooperation. Most important of them was Internal and External research “Development of mathematical competencies in higher education institutions within socio-economical context”, which was conducted in collaboration with the University of Siauliai. Seeking to identify the needs of the labour market and integration of professional competences of mathematics in border regions, research was carried out on the external demands of the labour market and employers who represent the need of qualified specialists with mathematic knowledge and skills. A questionnaire of this research consists of three parts. More interesting results come from Part 1 “Attitude to the mathematics” (self-assessment of mathematical abilities; conformity of mathematics at higher education school with a student’s needs; mathematics in professional practice and assessment of practical potential of mathematics) (Balciunas, Macaitiene, 2011). Research showed that the mathematics has a high status. It is considered difficult to learn and yet, often without any detailed justification, it has a high value: problem-solving and thinking developing means; tool for describing the real world and revealing human potential (the knowledge and abilities of mathematics, mathematical thinking helped them to achieve more in their life) in working activities (the advantage of mathematics knowledge on the labour market). External research results also showed that the lecturers should explain examples of real life where is used particular teaching substance, to work out more practical content tasks and assignments, according to programme specificity and emphasize the applicability of teaching mathematic subjects in concrete speciality and programme, etc. The external research also marked the field of mathematics which could be arranged in adult further education.

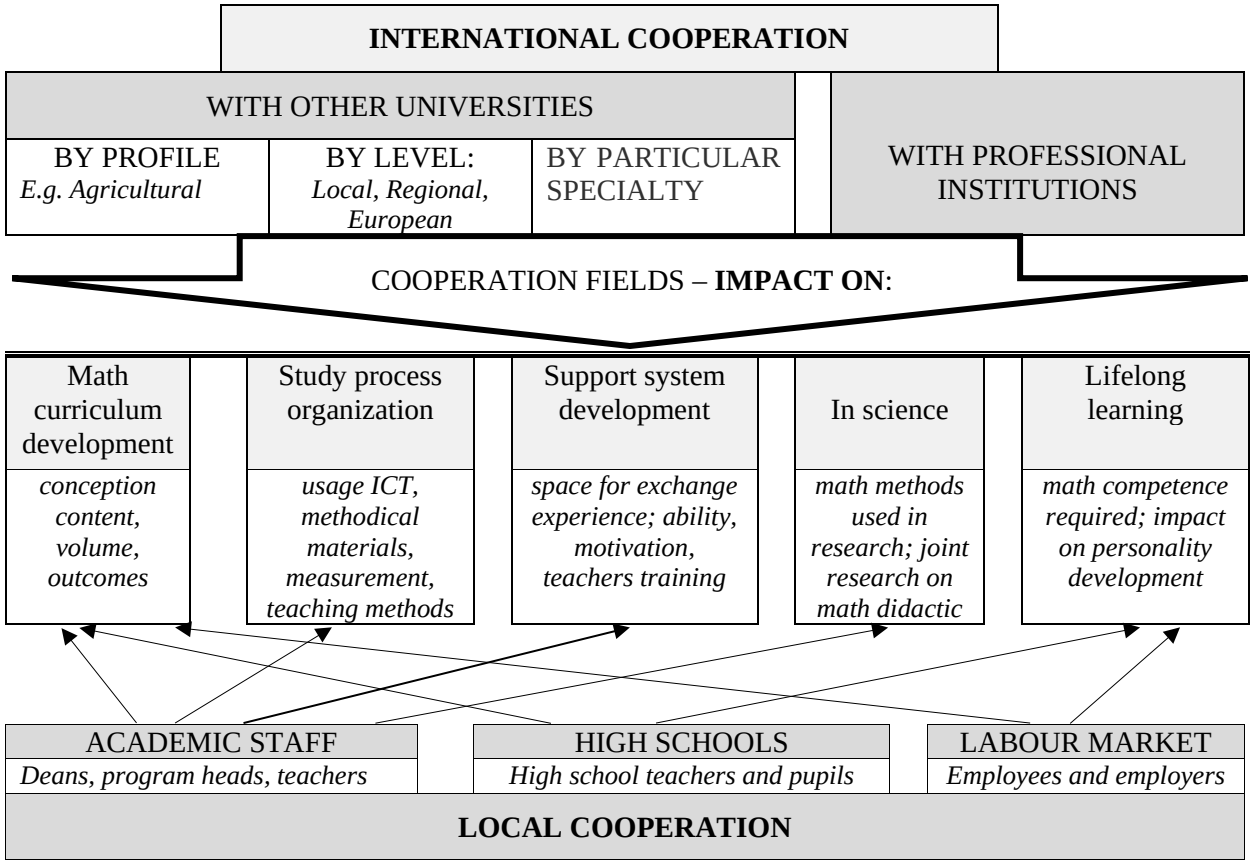

Figure 1. Cooperation forms and their impact on mathematics education process development.

Research on internal evaluation consisted of the analysis of SU and LUA mathematics study programmes and outlined to which extent the existing study programs correspond to the needs of the regional labour market. The main benefits from this research could be divided in three results groups:

- based on research results, recommendations for LUA (for SU as well) study program adjusting were created and consisted of four dimensions: program's outcomes, program's content, study process organization and study materials availability and accessibility to students;
- established methodology for determining the needs of the labour market and methodology for mathematics programs comparison and evaluation;
- created a database that includes an external study - the survey results, as well as summary information on LUA and SU study programs.

Based on these recommendations the aims of 15 LUA mathematics study courses have been revised and defined the outcomes of mathematics study programs. The contents of mathematics divided into three level modules: 1st level referable to the social science programs, 2nd - technological study programs, 3rd - engineering programs. Several courses supplemented by needed topics based on the internal research and on interviews with heads of programs and lecturers of special subjects. Based on SU experience, individual work of students was scheduled for every topic of mathematics. Recommendations for study materials availability and accessibility included a need to implement a common electronic base of methodological materials. Thus the learning materials' repository has been developed in Moodle environment.

To improve the quality and enhance the accessibility of mathematical competencies across border, innovative ICT based educational products have been created, tested and integrated: two open-system for long-term development - homework variants' generator including bank of homework tasks in Moodle and question bank for self-regulation and for tests in Moodle; methodological materials - home works examples and methodical material about the use of MathCad in mathematics. In the framework of this project new learning method was developed – how to use Moodle computerized learning system for self-directed learning practical application of mathematics. By analysing the demographical situation in cross-border region, the possible demand for the higher education in the

near future as well as education as export, was created methodological material in English. Special attention was paid to the practical application of mathematics. The results of external research show what mathematical competence is need to specialists of different fields. The advanced studies are offered to carry out through e-studies as additional courses with the focus only on practical application of mathematics and other themes: linear programming, probability theory and the statistics, numerical methods.

The cooperation within the Baltics network in agrometrics includes the work on common guidelines in mathematics and statistics. Work on common guidelines included evaluation of results of study courses and evaluation of contents and amount of study courses at EMU, ASU and LUA by four directions of study programs: environment, engineering, forestry and social sciences (Vintere, 2012). It could be mentioned that there is a synergy between results achieved in several cooperative networks. For example, the mathematics and statistics courses in LUA, EMU and ASU were evaluated using the methodology for mathematics programs comparison and evaluation established within MATNET.

With increasing number of students who continue training in other European universities in various exchange programs, such comparison becomes essential. Study programme coherence is an important factor in the common European education area.

For example, information on engineering mathematics courses gathered in the Table 1 shows the volume of the mathematics courses - division between theoretical lectures, practical seminars, laboratory works and individual work. Comparing the data it can be concluded:

- content of studies in the specialties of all the universities is similar except that the Lithuanian university mathematics program includes the mathematics practical us; the difference in the amount of studies is defined by time that is used in specific programs to study mathematics;
- the use of ICT in mathematics in practical work allows EMU to save several hours in comparison with LUA and ASU;
- in SU (also in ASU) the students individual work is planned carefully, separated according to which among the number of individual works are assigned.

One of the most important benefits from cooperation is creation the space and opportunity to present oneself and promotion the best practices and valuable examples using different tools. Thereby in the frame of the project MATNET High School Pupil Scientific Mathematic Olympiad and International Student Scientific Mathematic Olympiad was organised to encourage the motivation of the talented pupils and the best students that study mathematics for further carrier in this field and adaptation of knowledge and skills by gathering them together and setting the conditions for sharing scientific and cultural experiences.

The main objective of the network activities was to improve the teaching quality by means of exchanging teachers' experience, to learn about the problems and methods used to solve them in the neighbouring countries. Based on the partners' experience analysis to improve the study process in own university. In the frame of MATNET International conference „Mathematical competence development in higher education institutions" and two seminars-discussions (for university lecturers and high school teachers) were organized.

Baltic networking seminar on agrometrics and three International conferences were organized within the cooperation with EMU and ASU. During these conferences 40 reports were done: About common guidelines (courses content, volume, outcomes etc.) – 10; ICT in teaching and learning mathematics and statistics – 15; Agrometrics teaching methods – 10 and Mathematical and statistical modelling – 5.

The common interests of the mathematics and statistics education in Baltic States Universities were identified during the conferences and seminars. The main discussions were on mathematics competence level among the students and the necessary changes in mathematics study programs, studies programs coherence in the common Baltic education area. Another topic of the discussion was the mathematics and statistics programs relevance to labour market needs in Baltic States - how to prepare specialists who will be able to apply ICT and integrate mathematic competences for problem solving, data analysis; to raise awareness, competitiveness and qualification.

Table 1

Data about engineering courses volume

ENGINEERING	*EMU*			*LUA*				*ASU*[*]			*SU*			
Name of subject/s .... ECTS	*Linear algebra and analytical geometry- 4ECT Mat.An. 1-6ECT Mat.An. 2-6ECT*			*Mate I –5.25 ECT Mate II- 3.75 ECTS Mate III - 5.25 ECTS*				*Mathematics1- 7 ECT Mathematics 2 - 6 ECT*			*Mathematics 1-6 ECTS Mathematics 2-6 ECTS Mathematics3- 5,25ECTS Applied math–6 ECTS*			
Content	***T***	***P***	∑	***T***	***P***	***L***	∑	***T***	***P***	∑	***T***	***P***	***I***	∑[**]
Linear algebra	8	7	15	5	5	3	13	6	6	12	4	6	*10*	10
Vector geometry	4	7		3	3	1					6	8	*14*	
Analytic geometry of plane and space	6	8	15	4	6	2	19	8	8	16	5	6	*8*	25
Sets and functions	2	2		-	-	-								
Limit and continuity	4	3		3	3	1					4	6	*10*	
Derivative of a function of one variable	4	8	23	8	7	2	24	10	10	20	6	10	*16*	26
Indefinite integral	4	8		6	6	3					11	16	*24*	
Definite integral and its applications	2	4	18	6	7	3	31	15	14	29	4	5	*19*	36
Functions in several variables	6	8	14	3	3	1	7	8	8	16	7	12	*18*	19
Multiple and curvilinear integrals	6	14	20	2	2	-	4	-	-	-	7	11	*18*	18
Complex numbers				2	4	1	7	-	-	-	2	2	*6*	4
Differential equations	4	10	14	8	11	4	23	10	10	20	10	16	*28*	26
Numerical and functional series	6	12	18	8	11	3	22	4	4	8	12	14	*34*	26
Functions of complex variable	-	-	-	-	-	-	-	-	-	-	6	6	*18*	12
Laplace transformation and its application	-	-	-	-	-	-	-	-	-	-	16	10	*36*	26
Math practical use - Optimizations methods	-	-	-	-	-	-	-	9	13	22	-	-	-	-

[*]*There are data about Biomass engineering; bet ASU has other program for engineering with 15 ECTS*
[**]*The sum of the theoretical lectures and practical seminars (independent work not included)*

The status of mathematics and teaching at different universities was reviewed. The conception of teaching mathematics was determined based on the analysis made – the role and on purpose of mathematics courses in the agriculture education in mentioned three Baltic agricultural universities as well as in in cross-border universities. For engineering emphasis is on the structure, strictness of mathematics; simplest proofs can be provided, but application in the speciality is only an illustration. The course for environment specialties can be introduced through the tasks of applied nature; only several proofs and groundings are to be provided in order for the students to understand the structure of mathematics. Only conclusions-algorithms of applied nature are provided for forestry and social science specialties. The only difference is for forestry study program – the entire attention should be devoted to the solution of practical problems, but social sciences - to the task solution methods.

The contribution to the study process improvement - the diagnostic tests for the first year students and methodology for the testing and compilation of the results was created with the cooperation with EMU and ASU. These tests had been used for first year students at all partners universities and results discussed. The results revealed that while the students' abilities are becoming worse and worse. Using

these tests for several years can be determined student competence dynamics. Depending on it, the appropriate math course development planning is possible. The other benefit from these tests - basically all students spend only one - two years to acquire the basic course in mathematics. Unfortunately the frequent poor results cause expulsion from the university. From this point of view universities should work on making the mathematics studies more attractive, as well as prevent lack of knowledge caused by insufficient work at school or college. Diagnostic tests provide possibility to identify topics that more problematic for students and has not learned enough at the school or college. For example, ASU students can learn these topics by attending preparatory courses, but the LUA students have the opportunity to improve competence in mathematics through e-courses in Moodle. For its part these courses were created in cooperation with SU with aim to improve the quality and enhance the accessibility of mathematical competencies across border.

Diagnostic tests play an important role in comparison first-year students' mathematics competence among the universities. Of course, the results of the high school graduates in each country are collected and made publicly available, but none of the partner countries do not have information on how these students then are distributed between universities. This problem is crucial in a country where two or more universities offering programs in the same specialty. For example, the situation develops so - in one university the right answers in diagnostic tests have shown 80% of first-year students, the second university - only 35%. This means that the second university should make considerably more effort to both university students would have similar powers, such as additional contact hours, e-learning materials, individual working materials, topics to be acquired only by using mathematical software etc.

Mathematics is becoming a topical issue also in the lifelong learning context. To raise awareness, competitiveness, qualification for users, beneficiaries and stakeholders training courses for small and medium enterprises have been organized within MATNET. During the course lecturers found that adult education methodology is different from the university didactics. This experience was a new for the LUA teaching staff.

Conclusions

Working together teachers from all partner universities have shared research and practical experience on several mathematic education process aspects. LUA experience in cooperation with other Baltic States universities shows that learning about the problems and methods used to solve them in the neighbouring countries and exchanging teachers' experience, motivates to improve the mathematics education process particularly with regards to curricular development and teaching quality. Evaluating the cooperation experience and the progress achieved at Latvia University of Agriculture and its impact on mathematics education development, several conclusions could be made:

- In cooperation with three Baltic States universities was covered all the mathematics education aspects - mathematics curriculum development at university, study process organization, study support system as well as mathematics in the lifelong learning context.
- Progress achieved in collaboration with the SU which have the most significant impact on the development of the study process are: the methodology for determining the needs of the labour market and methodology for mathematics programs comparison and evaluation; recommendation for study programs readjusting; preparatory courses; methodologies for students un high school pupils Scientific Mathematic Olympiads; experience in cooperation with labour market etc.
- The most important attainments in cooperation with EMU and ASU are: mathematics teaching conception; diagnostic tests for first year students; methodology to evaluate the ICT usage in mathematics studies etc.
- By evaluating the experience of the cooperation, one can see the strengths and weaknesses of each partner university. E.g. EMU has knowledge and practical experience in blended learning organization, LUA has experience in usage of e-environment in study process organization. Both mentioned universities have been integrated MatCad in mathematics studies and have knowledge about mathematical software and experience on easiest use for the students. ASU have big experience in mathematical modelling and usage of agrometrics in agricultural

sciences, but LUA – about statistical methods. SU, ASU and LUA have capacious didactical materials. Teaching of mathematics and statistics is in one department at EMU, SU and ASU. ASU has experience in work with foreign students, but EMU has begun to look for new methods in teaching mathematics using ICT. SU and ASU have more experience in students' individual works planning.

- This means that partners' universities have the potential to learn each from another. It also outlines future opportunities for cooperation which should be continued in four directions: at the department level, between academic staff, between students and in science.
- In author's opinion, the possible directions for further cooperation in mathematics would be work on interdisciplinary study programmes, gathering the experience on applied software in mathematics studies, development of a common database for studies, etc.
- Based on the latest theoretical knowledge of mathematics and its role in higher education, an important future task would be collection of mathematical and statistical modelling methods.
- No less important is the sharing of teaching and learning new experiences, developing joint methodical literature, e-communication, creation joint e-learning materials for students' independent work etc.
- In author's opinion, the perspectives include common research on several organizational aspects of mathematics studies process, e.g. the approaches to develop cognitive development of students, didactic aspects of e-learning, promotion of the development of the competences necessary for the labour market, etc.

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