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The model of agroengineer and its implementation in applied higher education

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Abstract. The curricula of agricultural engineering and Professional Standards defining the skills and competencies have been evolving continuously to cope with the social and economical influencers. The objectives of the paper are to report on the development of the biosystems engineering program at Estonian University of Life Sciences and to enhance the model of agroengineer by defining its skills and competences. A series of 5 seminars were organised by the university. A total of 54 experts attended, they were either agricultural manufactures, processors of agricultural produce, suppliers of agricultural machinery or others with deep connections to agriculture. The experts were given the task to amend the statements presented in the professional standard of Specialist of agricultural machinery. The outcomes of the seminars were taken into account by the university. It can be concluded that there is an obvious need for engineers, technologists and managers with a higher education who would be competent in biotechnical system human – biological object – machine, i.e. they must have skills and knowledge about technologies, working principles, basic construction, legislation, and communication. The new 4-year professional curriculum of Biosystems Engineering applied for higher education addresses the need for technical specialists.

Key words: Agricultural engineering, agroengineer, education, curriculum, profession.

INTRODUCTION

Agricultural engineering has made a significant contribution to the world's food production. Mechanisation of agriculture has been ranked by the United States National Academy of Engineering as the 7th most important engineering achievement of the 20th century (Anon, 2000). It has provided the population with sufficient, safe and available food. However, agricultural engineering education has faced some serious issues during the last decade, such as problems with image, a reduced number of students, and insufficient funding (Briassoulis et al., 2010). Under the name biosystems engineering, the spectrum of agricultural engineering has been broadened towards the biological sciences arena (USAEE & ERABEE thematic networks). Similarly, the curricula of Agricultural Engineering have been evolving continuously in Estonia to cope with the social and economic influences. Though, the agricultural speciality subjects have been replaced by subjects of general engineering. Thus, the move has been towards the core engineering sciences in bachelor's, master's and doctoral studies.

The academic education and professional competence of an agricultural engineer – agroengineer – has been the subject for several researchers, pedagogues, and politicians in Estonia and other countries (Veski, 2010; Vartukapteinis et al., 2010; Romanenko et al., 2010; Naprstkova, 2010; Beitere & Šelegovskis 2008; Čivčisa et al., 2005). The biological resource and technological capabilities of production varies by regions. However, according to the philosophy of free movement of labour (specialists), measures have been applied for the academic education, qualification and mobility of agricultural engineers (EurAgEng; FEANI; USAEE 2006a). In order to improve the quality of higher education, attempts have been made to create adequate models of specialists (Zuyeu & Kachurka, 2010; Nadeejev, 2004; Paršina & Maruštšak, 2007).

Both education and work experience are relevant in the model of an agroengineer. These are tied together by the qualification framework. According to the Professions Act (2008), the Estonian Qualifications Framework has 8 levels, whereas level one is the lowest and level eight is the highest. Descriptions of the qualifications levels are identical to the European Qualifications Framework level descriptions. The aim of the Estonian Qualifications Framework is to develop a framework encompassing all qualifications in formal education (general, vocational, higher, and adult education) as well as vocational and professional qualifications (Peets & Käis 2010). The state recognised qualifications have to (1) be defined in a learning outcomes based qualification standard (curriculum or professional standard (Anon, 2009)), meeting the requirements of the national framework standard(s) (if applicable); (2) have state recognised awarding institution (educational institution, professional association, etc.). For the profession of an engineer there are valid standards in Estonia. The professional standard of agricultural engineer (Anon, 2009) defines knowledge, skills, and attitudes of the agricultural engineer as agreed by the concerned institutions and specifies three levels: agricultural engineer (Eng), diploma agricultural engineer (Dipl Eng), and chartered agricultural engineer (Chart Eng).

A recent development at Estonian University of Life Sciences is the introduction of a new 4-year professional higher education program 'Biosystems Engineering' aimed to produce technologists and managers for agricultural enterprises.

The average farm size increases, this trend is steeper in Estonia than the average in Europe: 73% of farmland can be found in farms the size of which is over 100ha and more than 75% of dairy cows are housed in herds of at least 100 animals (Kaldvee, 2010). The average farm size is 315ha (legal person) and 21.5ha (self-employed entrepreneur) in Estonia (Statistikaamet, 2010). Thus, there is a need for specialists who could manage the production technologies and equipment.

The objectives of the paper are to report on the development of the biosystems engineering program at Estonian University of Life Sciences and to enhance the model of agroengineer by defining its skills and competences.

METHODOLOGY – SEMINARS WITH STAKEHOLDERS

A great impetus towards the development of the curriculum of biosystems engineering at Estonian University of Life Sciences came from agricultural enterprises. In order to meet their requirements best, four seminars were organised by Estonian University of Life Sciences within the project 'Integrating the curriculums of agriculture and technology – biosystem engineering and product and technology development' in November and December 2009. A total of 54 experts attended, being either agricultural manufactures, processors of agricultural produce, suppliers of agricultural machinery, or others with strong connections to agriculture. An additional seminar regarding practical training of students was conducted in April 2010 with 9 persons representing the stakeholders.

Most of the experts were graduates from Estonian University of Life Sciences. In the selection of experts their social activity and how well they were known were important aspects, so the experts were also either heads of structural units or leading specialists.

All the seminars began with a short introduction of the participants and an overview of the contents and aims of the project 'Integrating the curriculums of agriculture and technology – biosystem engineering and product and technology development'. The skills and knowledge required from a future employee were discussed from an entrepreneurs' point of view. The experts' role in prioritising the student's skills (subjects) and in offering other propositions and solutions for the improvement of the curriculum was explained to the participants.

At the seminars the participants were given the following materials, which were explained in further detail:

1) Extract from the Standard of Higher Education;
2) Study outputs of the professional higher education level;
3) Statements from the professional standard which the curriculum of Biosystem Engineering was based on.

The entrepreneurs were asked to amend the statements presented in the professional standard of Specialist of Agricultural Machinery (Anon, 2008), i.e. make additions to it, change the relative importance if needed, strike off from it, etc. Following the standard the subjects were structured as follows:

- General skills and knowledge – legal acts, customer service and communication, leading of work groups, work environment, computers, and languages.
- Main skills and knowledge – general technical, metal-working, agricultural machines and equipment, usage of electrical and heat energy in agriculture, plant cultivation, livestock keeping, maintenance and protection of melioration systems, planning of buildings and requirements, economy.
- Additional skills and knowledge – driving cars, tractors and other vehicles, wood processing machines and equipment, construction machines and equipment, horticultural equipment, silvicultural machines, personal skills and capabilities.

RESULTS OF THE SEMINARS

The results of the comments, observations and suggestions amending the professional standard are as follows:

- Professional area of the specialist: in addition to tuition about cars, tractors, agricultural machinery, and other types of mobile machinery there have to be subjects about farm equipment, food and preservation technologies, and also electrical equipment.

- Main focus of work: in addition to planning, organising and instructing the use of machinery, and planning the needs of the work force it is also important to learn the basics of different technologies, processes, and logistics.
- General skills and knowledge: labour legislation, occupational safety, working environment, leading work groups, and motivating workers. In addition to English and German, Russian should certainly be taught as well.
- Main skills and knowledge: understanding and reading drawings, the usage of appropriate software. The main focus of teaching agricultural machinery and equipment should be on their working principles and basic construction. Local fuels, heating installations and systems, electronics and automatics have an important role in electrical and thermal energy studies. In plant production: organic farming, manure management, production of feed stuff, livestock farming technologies, and feeding. Concerning buildings: evaluation of condition, maintenance, reconstruction, and demolition are relevant.
- Additional skills and knowledge: it is important to drive cars, tractors, and other mobile machinery. Under personal characteristics logical thinking, the need for achievement, and conscientiousness were stressed.

The experts had different opinions of the relative importance of speciality subjects. It was suggested to apply specialisation, e.g. teach one year plant production and the other year livestock related subjects. The experts selected the weights of speciality subjects in the range of 600 hours. The results are demonstrated in Table 1, where the number of credit points (ECTS) is calculated based on the mean number of hours.

Seminars about practical training related issues had the following outcome:

- Health and safety – instructions and manuals have to be organised jointly between the university and enterprises. Each trainee should have two instructors. The company should do additional training according to its specifics. The student must have a valid permit from an occupational health doctor prior to training period. Permit for handling of plant protection products.
- Wages – it was agreed the student should get paid for the job. If the student has a strong will to work, the wages should be above the minimum. Depending on the student, national average wages could be paid. Students who lack the will to work will not be accepted to field training. Pay on a piecework basis should be used. Implementing a unified system has to be considered.
- State aid – was generally considered advisable. It motivates the instructor and allows increasing the student’s wages.
- Accommodation, catering, and social issues – non-work conditions at work are determined by the regulation. Accommodation arrangements include furniture and kitchen. Good meals are provided at work. Plenty of leisure activities are available.
- Additional points – minimum time of work at one company is two months. The entire training period should be carried out at a single company. Must have a tractor driver’s licence (training is provided at the university). Russian language skills are important.

Table 1. Relative importance of subjects as selected by the stakeholders.

Subject	Number of hours			ECTS
	Min	Max	Mean	
Plant production	**250**	**300**	**270**	**20.8**
Plant	30	200	102	7.8
Equipment	100	220	168	12.9
Technology	61	135	93.6	7.2
Selection	36	48	42.8	3.3
Calculation	7	45	34.8	2.7
Buildings	4	45	16	1.2
Device	39	100	74.4	5.7
Selection	13	30	19.8	1.5
Usage	13	45	28.8	2.2
Service	13	40	25.8	2.0
Livestock	**250**	**300**	**280**	**21.5**
Animal	30	240	116	8.9
Equipment	60	250	164	12.6
Technology	30	160	94	7.2
Selection	10	50	32.6	2.5
Calculation	10	60	32.2	2.5
Buildings	10	50	29.2	2.2
Device	30	100	70	5.4
Selection	10	35	23	1.8
Usage	10	35	25	1.9
Service	10	40	22	1.7

STRUCTURE AND OBJECTIVES OF THE RESULTING CURRICULUM

The results of the seminars were taken into account in the completion of the curriculum of Biosystems Engineering at the university. The curriculum was finalised in the spring of 2010 and the first group of 20 students enrolled in September 2010.

The structure of the 4-year professional higher education curriculum is as follows:

- base module 28 ECTS credits,
- area module 59 ECTS credits,
- speciality module 58 ECTS credits,
- elective speciality module 67 ECTS credits (27 ECTS credits to be elected),
- practical training module 45 ECTS credits,
- optional subjects 8 ECTS credits,
- final thesis 15 ECTS credits.

The objectives of the curriculum are creating possibilities for students to get a technical base education and specific skills and knowledge necessary for a technical specialist in the field of production and processing of agricultural products. Training technologists, technical and other specialists, maintenance service managers, sales managers, product managers, consultants, etc. for manufacturing or development enterprises whose area of responsibility is planning, organising and supervising the use of machinery for the production and primary processing of agricultural products, workforce requirement planning, work supervision, accounting, communication with customers and suppliers. The acquired professional higher education enables students to apply for a relevant professional qualification after two-year professional work experience. Students having fully completed the curriculum may proceed to Master's studies, having acquired abilities for personal development through lifelong education.

Learning outcomes of the curriculum define that the student having followed the curriculum:

1) has a mindset to protect environment, maintain and promote rural and technical development;
2) has a systemic overview of the basic concepts, theoretical principles and research methods of the biosystem (environment-plant-animal-human-machine);
3) can recognise interdisciplinary connections between technical, environmental and biological sciences;
4) knows the topical problems and application possibilities of machinery for handling biological raw materials;
5) is able to verbalise professional issues and to analyse and evaluate various solutions;
6) is able to collect information independently using appropriate methods and tools, process it using mathematical statistics methods and to interpret the results critically and creatively;
7) is able to select and use appropriate methods and technologies within a set framework for resolving professional tasks and to evaluate potential consequences based on obtained information;
8) is able to demonstrate initiative in starting and preparing research and funding projects and display responsibility, leadership and teamwork skills in implementing them;
9) possesses the communication skills, information and communication technologies necessary for technical specialists;
10) is able to communicate technical issues verbally and in writing in Estonian and the acquired foreign language(s) and to participate in professional discussions;
11) is ready to be an active participant in civil society and to have tolerance for the diversity of attitudes and values;
12) is able to evaluate the role and consequences of professional activity with respect to societal and ethical aspects;
13) is able to apply the acquired knowledge and skills working as a technical specialist and to apply for a professional qualification;
14) is able to continue studies in Master's studies and be aware of the need for lifelong learning.

RESULTS OF CURRICULUM ANALYSIS OF THE FOLLOWING THE FEANI REQUIREMENTS

The program of Biosystems Engineering taught by Estonian University of Life Sciences was compared with the FEANI (European Federation of National Engineering Associations) requirements (USAEE, 2006b).

In general the program corresponds to the FEANI recommendations. However, there are some disagreements: the actual amount of mathematics is smaller than the requirement (15 versus 24 ECTS). This is the case in many programs throughout Europe as it was found in the ERABEE workshop in Prague in April 2010. The amount of engineering science subjects is close to the upper limit (81 ECTS) or slightly above depending on the amount of electives. The number of credits for the agricultural/biosystems sciences is within the required range of 36–45 ECTS. Characteristic to this program is the large part of training in the value of 45 ECTS.

CONCLUSIONS

The following conclusion result from this work:

- There is an obvious need for highly educated engineers, technologists and managers for agricultural enterprises.
- These technical specialists have to be competent in biotechnical system human–biological object–machine, i.e. they must have skills and knowledge about the technologies, working principles, basic construction, legislation, and communication.
- The new 4-year professional higher education applied curriculum Biosystems engineering addresses the need for technical specialists.

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