THE COURSE TRANSPORT, HANDLING AND MANIPULATION MACHINERY IN ENGINEERING EDUCATION

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Abstract. This paper is focused on the pedagogical approach in teaching of the course Transport, Handling and Manipulation Machinery in the frame of the study programs for students at the Faculty of Engineering of the Czech University of Life Sciences Prague. These are mainly the following study programs: Technological equipment of buildings, Waste disposal technology and techniques, Agricultural machinery and Technology and Environmental Engineering. Machines and technical equipment in operations corresponding to these study fields are, e.g., agricultural harvesting machines and lines, post-harvest and processing lines, almost all of the major lines in the food industry, machinery and lines for waste treatment, etc. This article summarizes the teaching experience, which has been obtained in the years of teaching this technical course for 718 students during the last twenty years. This article highlights the main areas of this course which are adapted to the needs of various above-mentioned fields of study. There is emphasized particularly continuity of lectures, exercises and independent individual activities in the frame of study, including the knowledge obtained in operating practices. There are presented in this paper also the forms of assessment and verification of the students' knowledge and the exam results of Czech and foreign students.

Keywords: study, technical course, machinery, specialisations.

Introduction

History of transportation and material handling is very broad. Transport and manipulation have been accompanying people at a technical level equivalent to the level of their development throughout their existence. Various simple mechanical handling tools to facilitate human work as levers, chutes and their applications have been used since the times of ancient Egyptians and further developed in the Greek and Roman civilizations. From the Middle Ages pulley mechanisms, cranes and other similar equipment are known in various fields of human activities.

About development of handling techniques, it is possible to speak since the industrial revolution. Development of many industries, accompanied by an ever-increasing rate of production, growth of labour productivity and technical maturity of all related disciplines, enforced continuous improvement of transport and handling. The rapid changes in all technical fields caused the use of electronics, computer and automation technology in the second half of the 20th century. Transport and handling becomes a branch of science which has got into the fascinating levels nowadays, and in practical life we can not imagine human activities in the present stage of civilization without transport, handling and manipulation.

Development of many new fields of study at the Faculty of Engineering (FE) at the Czech University of Life Sciences Prague (CULS) brought the need to improve the students' knowledge in techniques for handling and transport. Many new ideas for improvement of the study programs related to Biosystems engineering present importance of courses with theoretical background applied in engineering branches [1; 2]. This is especially the issue of technological processes and techniques used in agriculture, forestry and subsequent processing fields such as food industry, feed industry, and wood processing, including technologies and techniques for waste management and more. There are transport and handling processes, machinery and equipment, used mainly inside production, storage and other specialized industrial halls. Machinery and equipment used for this purpose, particularly inside buildings for production, storage and other production operations have many common features and principles.

Materials and methods

The course Transport, handling and manipulation machinery (THMM) includes theoretical, technical, energetic and practical information about transport and manipulation machinery used mainly as a part of logistic systems in agriculture, food industry, waste processing, building industry etc. This course is a very important source of basic knowledge and skills for a future chartered (accredited)

engineer by the Czech Chamber of certified professional engineers and technicians active in contraction and designing [3].

Problems of optimal arrangement of study and future development of students knowledge is the main task for good educational background of each study program and course at universities [4-6].The course consists of lectures and seminars. The content of lectures during the semester divided in twelve weeks is in the following text.

1st lecture. Introduction; terminology; logistics.
2nd lecture. Transported materials; classification of transport and handling machinery. Palletisation and containerization in systems of waste management.
3rd lecture. Mechanical conveyers - belt conveyors.
4th lecture. Mechanical conveyers - chain conveyors.
5th lecture. Channel conveyors; push-plate conveyors.
6th lecture. Screw conveyors.
7th lecture. Shaker conveyers; gravity conveyors.
8th lecture. Bucket elevators; transport roller systems; overhead conveyors; cable ways.
9th lecture. Machinery and equipment for transport of liquids; hydraulic transport of solid loose materials.
10th lecture. Machinery and equipment for transport of liquids; hydraulic transport of solid loose materials.
11th lecture. Pneumatic conveyers.
12th lecture. Stationary lifting and handling machines and devices. Lifts.

The lectures form the background for the seminars. Seminars are used to develop and to train the knowledge from the lectures and recommended literature. During seminars and homework students are also required to develop an individual project showing application of transport, handling and manipulation machinery in the form of a printed report. Seminars are interactive and students finally present their projects also for their classmates. The classmates comment the presentation. Rather popular and very interesting for students is occasional participation of specialists or foreign teachers in lectures and seminars, e.g., from Greece, Germany, Italy, Latvia, Portugal. They bring new ideas and information to students and usually also use another form of presentation in foreign languages.

The problems, which students have to solve in their homework (report), should be focused on applications mainly in their study specialisation, but it is not obligatory. The question of student's own interest is also important, as well as the availability of the information in a company, factory etc. The basic percentage distribution of the selected topics of individual works of students from the recent eight years is presented in Table 1.

Table 1

Topics of individual students' works

Topic of individual work	Number	%
Agricultural machinery – postharvest technology and storage in farm	31	14.4
Technological equipment of buildings in which:		
- animal houses	9	4.2
- feed production factory	6	2.8
- food production, bakeries, breweries, slaughterhouses, soft-drinks, etc.	37	17.2
Waste management and processing in which:		
- solid waste separation	16	7.4
- solid waste processing and recycling	23	10.7
- waste burning stations, heat production	10	4.7
Water and waste water transport	10	4.7
Transport and manipulation machinery	14	6.7
Building industry (cement and concrete production, timber processing)	28	13.0
Manufacturing industry (steel, electro, glass, plastic, etc.)	27	12.6
Other branches and applications (post offices, printing companies etc.)	4	1.8
Total	215	100

Currently, due to the new structure of education at the Faculty of Engineering great attention is paid to the preparation of separate and individual study during the semester. It is partly a result of a new concept of a three-level system of education. The course THMM includes students in the second level of study, i.e., in the Master study level, for the majority of them.

Distribution of each phase of study according to the students' activity either in the university in contact hours of study with the teacher, or by individual study at home of the course by the credit system is presented in Table 2.

Table 2

Schedule of credits

Activity	Credits	Hours
Lectures	1	24
Seminars	1	24
The semestral project	1.4	35
Individual consultations	0.6	15
Home preparation and study	1	24
Study for examination	1	28
Total	6	150

Course completion by students' assessment and examination is a very important part of study. To be eligible for the exam the student must participate in contact teaching, submit in time the individual project on THMM and present the results of the project during the seminar. The eligibility to participate in the exam is written in the students´ University Study Report before the exam with words pass-eligible. Once the student is eligible for the exam, the exam consists of written tasks and oral tasks. The scale of students' knowledge assessment is presented in Table 3.

Table 3

Scale of assessment

Local Czech grade	Quality description of grade	ECTS grade
1	Excellent	A
2	Very good	B
3	Good	D
4	Failed	F

Results and discussion

Main statistical values calculated from the results of students' examinations expressed by mean values of marks during last twenty years in all different forms of study are presented in Table 4. Students and their results are divided according to the form of study as Regular students of daily study programs, Distance students (combined form of study), Erasmus and other foreign students, who study in the English taught course. The last column in Table 4 informs about the number of students, who did not passed the examination in the first attempt and who had to repeat the examination again.

Table 4

Results of students' assessment

Form of study	Number of students	Mean value of marks	Standard deviation of marks	Students failed in examination	
				Students	%
Regular students	584	1.95	0.27	76	13.01
Distance students	101	2.01	0.50	12	11.88
Erasmus and other foreigners	33	1.27	0.27	1	3.03
Total number of all students	718	1.97	0.43	89	12.40

The best results of examination are achieved by students from abroad either coming in the frame of Erasmus program from European countries or from non European countries, which are regular students of our Master study program Technology and environmental engineering, taught in English.

The course Transport, handling and manipulation machinery is one of the compulsory optional courses. The results of students' examination expressed by the mean value of marks during the last twenty years are presented also in Figure 1. The tendency of students' marks is slowly going down, but it is not statistically significant which means that the level of students' knowledge is only a little bit improved. We could try to find the explanation. Maybe, it could be partly caused by the improved form of teaching, new available literature [7-9], higher interest and activity of students or their stronger motivation to study.

In analysis of this issue attention was also paid to the potential impact of the size of a study group on the study results. The number of students in the course varies considerably during the last years. Lectures are solved at FE together for all students enrolled in this course. Seminars are divided into study groups, which size is usually no more than 20 to 25 students. In some years, the number of students is smaller and therefore the number of students in a study group is smaller as well. The minimum acceptable number of students is usually 8 students in the seminar group. This effect was also put into the context with classification of the results of study and it is expressed in Fig. 2.

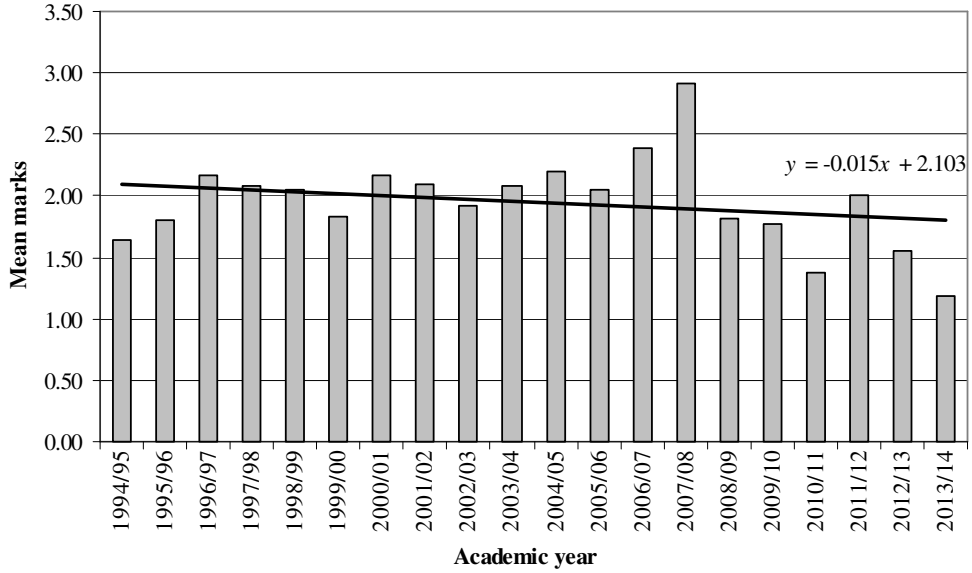

Fig. 1. **Students' mean value of marks during the last twenty years**

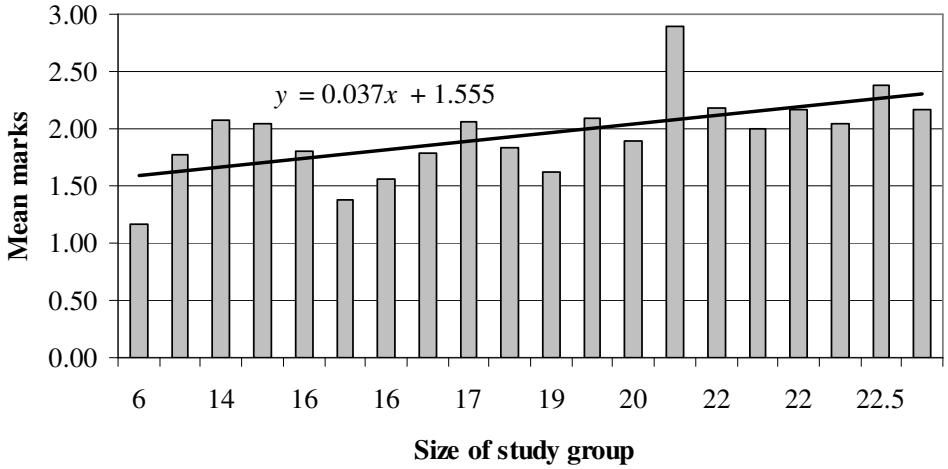

Fig. 2. **Influence of number of students in study group on study results**

Results of examinations can be only one of the aspects which confirm the importance of the course THMM. It is also important that students recognize that this course can help them in the preparation of Diploma Thesis. Many machines and technological equipment mostly arranged in the production chains function thanks just only to good construction of transport machines and elements like belt and chain conveyors, screw conveyors, chutes or pumps with pipelines etc. Students after the

study of the course THMM do not only understand the principles, but they are able to calculate the main parameters of these machines or choose suitable machinery from the large offer in the market.

Conclusions

Graduates of the course THMM acquire theoretical master-level knowledge of technologies and machinery used for transport, handling and manipulation in agriculture, in all branches of Biosystems engineering and in other fields of industry. They have systematic understanding of the studied problems, especially of individual requirements on work operation, their energy demand, properties of processed materials, adjustment of mechanisms with respect to optimum work quality, and evaluation rules of economic efficiency of machinery. Their knowledge is further used and expands in courses oriented at structural design of machinery, in problems of technological requirements, and at organization, management and optimization of production processes.

Graduates of the course THMM are able to apply the acquired theoretical and practical knowledge in solution of problems related with optimum employment of transport, handling and manipulation machinery in practice oriented at production processes, provision of services, and at machinery selling. They know how to use new technical and scientific publications and they can interpret them to their customers. There are many companies which provide different type of business in these branches and graduates can be successful in the work at different positions in these companies.

Positive influence on successful study and on the final results in examination has partly the smaller size of the study group and mainly obligatory semestral works prepared by students in the form of individual projects and presented in the seminars for all classmates. Quite important motivation and challenge for students to study with pleasure technical problems of transport, handling and manipulation machinery is direct application of the studied problems in the solution of Diploma Thesis or in other study courses.

Very important motivation to study this course is for students who suppose to be designers of technological equipment of buildings for applications in agriculture, food or feed industry or waste processing technology. They need to be able to calculate and design new technological equipment, which is based mainly on manipulation and handling techniques. It is one of inevitable conditions for future designers accredited by the Czech Chamber of certified professional engineers and technicians active in contraction and designing.

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