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To cite this article: A. Váradiné Szarka 2016 *J. Phys.: Conf. Ser.* **772** 012053

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Dual education and industrial cooperation in electrical engineering

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Abstract. Dual education in higher education is a new system in Hungary introduced by Mercedes Benz with cooperation of Kecskemét College. In the new system companies support certain number of students and provide them strong practical education in their field. Students applying successfully for dual education study together with non-dual students at the university, so they go through the same university courses as their non-dual colleagues, but while non-dual students' academic year includes 2x14 weeks active semester and 2x6 weeks exam session, all over 40 weeks, dual students have 48 working weeks including study at the university and practicing at the company. The main question of the success which one is the most effective model to be applied. This paper summarises 2 models of dual education with their advantages and disadvantages and also it presents practical realization at the University of Debrecen with special attention to measurement and instrumentation. Dual education in BSc level electrical engineering course cooperates with 6 multinational companies of the region in four specialization. Dual education also has great impact to the modernisation of engineering education. Detailed study of dual education in field of instrumentation and measurement is provided in the paper.

1. Introduction

Dual education is a well-known and successful practical oriented educational form mostly in German speaking countries and around for a long time. This education aims to educate professionals for certain dedicated industries mostly in secondary and technician levels. As this type of education is supported by a defined company, students take part in a shared education, one part of their education runs in the school, this covers mainly the theoretical education and the other part runs in the industrial plant of the cooperating company which makes this education a highly practical oriented one. This type of education seems to be a really good composition of theory and practice, but the lune always has a shine and also a dark side. In this system students will be specialised in a narrow field of one defined industry which is a real advantage in case of being employed by that company, but it can also limit their selection or changing possibilities when they are not employed or don't want to be employed by that company where they were dual students during their studies. The profit oriented companies obviously aims to make a strong selection of employees, so their strategy is supporting education of a relatively high number of students, which is a really good opportunity for those joining this type of



education, but at the end of education in most of cases the company employs only few students, the best ones of course, and all the other students are stressed to find job in another industry in which they are not or only partly experienced. Therefore this type of education has strong supporters and oppositions even in secondary level education.

The Mercedes Benz company has founded a large plant in Hungarian town Kecskemét in 2008. They suffered from leak of well specialised employees in all levels including secondary and higher levels. Therefore according to German practice they have introduced a dual education in Kecskemét, but not only in secondary but also on bachelor level.

2. Predecessor of dual education in higher engineering education in Hungary

Before the Mercedes Benz's dual education was introduced in Kecskemét some educational cooperation (like sandwich courses) between industry and universities already existed in Hungary. The most successful type of such education is the so called "cooperative education". This is a classical sandwich course on bachelor level, the main representative of this type of education is University of Óbuda in Budapest which is the biggest engineering educator in Hungary on BSc level. BSc engineering courses in Hungary include 7 semesters. Students wishing to join cooperative education apply for 1 or 2 semesters practical education to industry after they have completed the 6th semester at the university. In the last 1 or 2 semesters they work like interns for the company while they are completing their thesis project which is defined by the company. At the end of their training period they defend their thesis and get their degree. In this system students finish their studies in 7 or 8 semesters depending on number of practical sandwich semesters, and at the end of their education the company has got a ready for work professional. Why this system is good? Universities train and work with students for 6 semesters in theory and in laboratories, students can participate in international mobility programs and/or student scientific or industrial projects, etc. Companies select cooperative students at the very end of their university education, in the 6th semester, when students already have some results and professional knowledge, so practically the usual HR strategy can be applied by the company for selection, and the company still has 1 or 2 semesters to decide if the selection was really for use of company. More than 95% of cooperative students are employed by their company, so we can state that the selection process and practice is excellent and most of the companies prefer this type of educational cooperation. In the official cooperative education university is also interested as the companies provided some additional support to universities. The additional advantage of this system is the close educational cooperation between the university and industry, so the educational plans (theoretical and practical) are harmonized and evaluated, thus the quality assurance, evaluation and feedback are important and successful parts of this system.

The new credit system in higher education starting from the begin of 2000's resulted new trend in intern system and in the practical education in Hungary. Besides of the traditional cooperative education many companies announce shorter or longer intern positions for full-time students. Using the increased freedom of credit system, students have possibility to compose their individual educational plan and they try to share time between the company and university, so number of interns are increased dramatically in engineering education in the last decade. By now more than 70-80% of third year engineering students have intern contract with industry, and practically 100% of MSc students also have such contracts. It means that these students work for industry minimum 20 hours up to 40 hours per week, but the industry and university have no any cooperation or harmonization of education, let's say they the university does not know about the internship of the student at all and there is really weak added value to the students education. The aim of the company in such system is to bring forward the introduction and preparation of new graduates in order to have a ready for work engineer by the time of receiving the diploma. Advantages for the companies are obviously, advantages for students are relative. From one side they are paid by the company, from the other side most of full time students working as intern for companies loose more than 1 semester in studies, so

most of them can receive diploma in 8th, 9th or even 10th and more semesters of their studies, so they work for much lower wages as intern in these extra semesters as they could work as graduated engineers. Also in most of cases educational results of these students are dramatically falling. Universities are suffering from this new trend as they lose the best students to work on projects with, and also they have to spend much more time for education of these students. So we can state that universities are not interested in the individual intern programs of companies and the long-time interest of students is also a question.

On the basis of the above ideas and the Mercedes Benz's practice dual education for higher educational institution of certain field was introduced by law in Hungary.

3. Two models of dual education in Hungary

The general dual education system is introduced for bachelor engineering education lasting 7 semesters. Main points of the system is the timeshare including 26 weeks university/college education plus 22 weeks industrial practice plus 4 weeks holidays in the first three academic years. Students have a contract with the company and they are paid by monthly basis from their very first day of studies in higher education. The monthly payment should be at least 60% of the minimal wage. The university and company also have contract and they can decide how the above described time frames are scheduled within a year.

3.1. Application procedure

Hungarian higher educational application procedure is a fully centralised system with a very complicated calculation of points collected from secondary school results, final exam results and some additional criteria. From the maximum 500 points 200 points come from secondary school results in two final years, 200 points come from the secondary school final exam results and 100 points can be collected by special results like sport results, professional and sport Olympiad results, extra language knowledge, social disadvantage or handicap, etc. Engineering courses require between 280 and 450 points from applicants depending on the institution and specialization. Nowadays the highest level is required at the Technical University Budapest mechatronic engineering course. In general we can state that there is a big gap in required points between Budapest and other parts/towns of the country which is partly a social problem.

All the applicants have to go through the normal application procedure and successful students can apply additionally to become a dual student, but the selection in this stage is made fully by the company.

Why the dual education is important for universities in spite of the fact that there is no financial interest and they lose the best students to work in research projects. The main advantage of the system for universities is the dramatic increase in number of applicants, thus increase of minimum required points which definitely increases the quality.

3.2. Kecskemét model

The first model was introduced by Mercedes and Kecskemét College, so it is called "Kecskemét model". In this model academic year includes 2 semesters with 13 active weeks each, 5 working days per week at the university/college. After the fall semester students spend 4-6 fulltime weeks at the company, and after the spring semester also 16-18 weeks while they receive all together 4 weeks off during winter and/or summer. In this system students go to university lectures and laboratories together with other, non-dual students, they study 13 weeks, but while non-dual students have 6 weeks exam session after each active semester, dual students have to go to work for the company. Dual students have to take exams in parallel with working in 8 hours per day in industry, which means that dual students have no official exam session, which makes their studies really difficult.

Advantage of this system is the clear and continuous time frame for school lessons and for industrial practice with 5 working days of each weeks either at the university or industry. Disadvantage of the

system is the highly separated activity of the two sides and missing of exam session. Figure 1. shows timing plan of Kecskemét model.

KECSKEMÉT MODEL																																																					
		September				October				November				December				January				February				March				April				May				June				July				August							
	weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	
Semester 1-6	University education																																																				
	Industrial practice																																																				
	University education																																																				
	Industrial practice																																																				
	Leave																																																				
Semester 7	University education					Final year project, final exams																																															
	Industrial practice																																																				

Figure 1. Kecskemét model of dual engineering education

3.3. Debrecen model

If we divide the above described schedule into days, a 52 weeks year including 26 weeks at the university and 22 weeks at the company will result 26x5 days all over 130 teaching days and 22x5 days, all over 110 working days. The 4 weeks leave is the same in both methods.

In the “Debrecen model” one week of the teaching semesters is divided into two parts from which students go to university lessons and laboratory 3 days and they go for the industrial practice to the company 2 days per week. As the fall and spring semesters include 14-14 weeks, students spend 80 days at the university and 60 days at the company. At the end of each active semesters students have 5 weeks (25 days) exam session when they have to spend their time clearly only for being prepared to exams and for taking exams. These 50 days for the exam sessions are included into the university’s time frame. Between June and September students have to spend the remained 50 days (10 weeks) at the company.

The main advantages of this system is the continuous contact and work with company from one side and having a regular exam session from the other. The main disadvantage of the system is the shorter working weeks at the university which means that the full class schedule should be included into the first three days of the week. The average contact hours at bachelor courses is 26, so students spend 7-8 hours per day at the university during an active semester. Figure 2. shows Debrecen model. Numbers in checks show number of working days per week to be spent at university/company/leave.

[illegible]

Figure 2. Debrecen model of dual engineering education

As we can see on the diagram the biggest disadvantage of the system is the early start of the practical education. The main question what companies can do with a first year student just leaving the secondary school and not having any engineering or technical knowledge. Most of companies decided to strengthen so called soft-skills of students in this period, like English knowledge, communication and presentation skills, working in team and multicultural environment

4. Dual education in field of instrumentation and measurement at the University of Debrecen

University of Debrecen has accredited dual electrical engineering course in four main specialization: (i) automation and industrial process control; (ii) electrical power networks and supply; (iii) instrumentation and measurement; (iv) electronic industry. Six multinational companies from East Hungary have joint the programme: E.On Hungaria; MSK Ltd., National Instruments; Jabil Circuit; Schaffler Group FAG Hungary Ltd. and RAFI Hungária Ltd. These companies aim to receive 2-5 students per year in dual education system, so all over 15-25 students can get the possibility to be “dual student” at this course. These companies have very high respect in Hungary therefore the number of applicants is very high in 2016, so probably the best students will be in this education.

System of practical education at companies is worked out in close cooperation with the university. In first step companies define departments/professional fields to be included into practical education. In the second step harmonization of company's plans with university's educational plans are worked out. Measurement and instrumentation is included into all the 4 fields but the ratios are obviously different. Focuses in measurement and instrumentation by fields are shown in the table 1.

Table 1. Main practical topics in measurement and instrumentation by dual education fields

Practical fields in dual education (Companies of the field)	Main topics in measurement and instrumentation practical education
Automation and industrial process control (MSK, FAG)	Sensors, instrumentation use and handling, error analysis
Electrical power networks and supply (E.On)	Power and energy meters, smart metering, diagnostics of power quality, electric shock protection, instrumentation for energy efficiency measurements
Instrumentation and measurement (NI)	Development of computer based instrumentation, calibration of instruments, accuracy, gain, offset, linearity, etc. Measuring error estimation, test stands
Electronics industry (Jabil, RAFI)	Testing methods of technology: ICT, flying probe, AOI, AXI, functional testing, JTAG testing, product and production diagnostics, ESD measurements

In the dual education system well defined topics of industrial practice are assigned to certain subjects of the university teaching plan. Thus each industrial partner includes some practice in measurement and instrumentation when student learn it at the university, but differences come of course from the activity orientation of companies. At the electrical engineering courses of the University of Debrecen measurement and instrumentation studies are relatively intensive, as it is shown in table 2. Some courses student have in the second, third, fourth and sixth semesters. In dual education system it means that companies also should focus to this structure and to provide some additional practical knowledge in the certain instrumentation discipline which is also included into the table 2.

5. Summary and Future Plans

Unfortunately in Hungary the higher education and industrial needs were in quite a distance from each other. Very few universities tried to answer companies' needs, and so more and more complains from industry side were directed to certain technical education. The industry is the customer of higher engineering education expressing its demands to have new graduates with up-to-date technical knowledge and abilities to shorten their initial learning period. But how the higher education can be motivated to listen this demand and moreover to do something new. There is definitely not a general good solution but first experiences of dual education introduced on BSc level underline its positive effects to the whole education. Universities are stressed to improve their teaching, to introduce more sophisticated subjects and themes, teaching materials have to be as closer as possible to industrial needs and requirements, some teachers takes part in practical training at their cooperating companies. From the other side 8-10 times more students apply for dual education as to the traditional one, so it seems that only the best students can study in such system which also increases the quality of engineering education.

The next step is introduction of dual education on MSc level.

Table 2. Cooperation between university and industrial studies in instrumentation and measurement

Study semester	Theoretical course	Industrial practice (the most interested companies name in the brackets)
2	Introduction into instrumentation <i>Oscilloscope, DMM, function generators</i>	Oscilloscope, DMM, function generators and other field specific basic instrumentation handling. (All companies)
3	Introduction into LabView programming <i>Basics of programming</i>	Practice in measurement controlling software development. (NI)
4	Measurement science <i>Measuring errors, error analysis and estimation methods, error distribution and error accumulation</i>	Industrial measurement and analysis methods in specific fields, calibration of instruments, inhouse calibration, test stations of the specific fields, like accelerated life testers, ICTs, power metering, etc. (All companies)
6	Sensors and actuators <i>Basic active and passive sensing methods. Basic sensors of electrical and non-electrical quantities: temperature, Hall-effect sensors, strain-gauges, etc.</i>	Sensors and transducers of specific fields. In process control field extended practice in mechanical quantities sensing. Electrical motors and drives. (MSK and FAG).
6	Computer based instrumentation <i>Digitalization of analogue signals, signal conditioning, signal transfer, data transfer protocols used in instrumentation, multifunctional data acquisition equipment, characteristics of analogue and digital input and output modules</i>	Computer controlled field specific instruments and measuring systems, like ESD, function verification testers, lifetime testers, hazard detection, etc. (All companies but very different specific field equipment is studied by companies)

Acknowledgments

Author wishes to acknowledge professional support of the electrical and electronic engineering fields of the University of Debrecen and the fruitful cooperation to industrial partner companies, namely sincere thanks are expressed to NI Hungary, E.On Hungaria, MSK, Jabil Circuit; Schaffler Group - FAG Hungary and RAFI Hungária for providing possibility to publish this paper.

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