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HOW TO REACH INNOVATIVE PRODUCT BY KNOWLEDGE TRANSFER?

Biljana MARKOVIĆ[1], Vojislav MILTENOVIĆ[2]

[1]Faculty of Mechanical Engineering, East Sarajevo, BOSNIA AND HERZEGOVINA
[2]Faculty of Mechanical Engineering, Niš, SERBIA

ABSTRACT
The aim of every company, in modern conditions for the foreseeing, is to become available at global market. Creation of an innovative (new) product represents the key to success in global environment, while team work and use of demonstrated results of existing educative models represent the condition for creation of such a product. This paper shows results of knowledge transfer and implementation of the educative model KaLeP in education of mechanical engineers in Serbia.
Major problem in modern world market is – how to create new innovative product which will fulfils all customers' requirements and expectations?
The above-mentioned means that new products are created in severe market competition which should fulfil customers' expectations, even their individual wishes, which as result has striving for "innovative production", and/or "innovative management". The only possible solution in such actual environment conditions is application of one of the global development strategies, integrated product development. It is only mean for obtaining better, innovative design solution which is nowadays primary objective of any company.
The objective of the university education of mechanical engineers is to impart the complex knowledge necessary for efficient product development in an industrial environment and to teach students the key abilities required for their professional life. Industry is searching for engineers with a university degree as a "problem solvers" and "creativity sources".
Keywords: Education model, integrated product development, innovative product and management, team and team work, transfer of knowledge.

1. INTRODUCTION

Major problem in modern world market is – how to create new innovative product which will fulfils all customers' requirements and expectations? Modern conditions of the foreseeing, and/or the market requirements impose to the economy of any country more complex tasks with respect to speed of mastering new products, their quality, design, productivity and flexibility. The above-mentioned means that new products are created in severe market competition which should fulfil customers' expectations, even their individual wishes, which as result has striving for "innovative production", and/or "innovative management".

The only possible solution in such actual environment conditions is application of one of the global development strategies, integrated product development (Fig.1).

It is only mean for obtaining better, innovative design solution which is nowadays primary objective of any company.

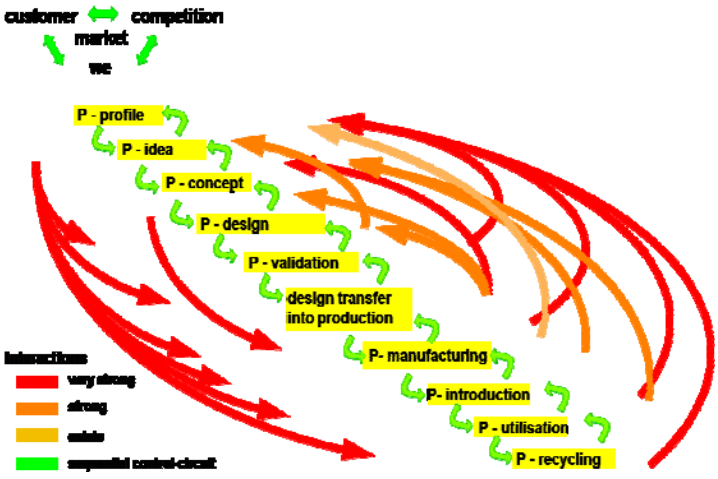

Figure1. Integrated product development process (A. Albers, IPEK)

In this paper has shown results of experimental research, which had validated through joint cooperation project, between students from engineering faculties in Niš and Karslruhe, which resulted with innovative products.

2. OBJECTIVE OF TEACHING PRODUCT DEVELOPMENT

Product development is one of the most complex and important stages in the value creation chain. The objective of the university education of mechanical engineers is to impart the complex knowledge necessary for efficient product development in an industrial environment and to teach the students the key abilities required for their professional life. Industry is searching for engineers with a university degree as "problem solvers" and "creativity sources". Especially those engineers are indispensable that are at all times able to cope with new problem situations due to their well-founded basic training of the acquired methodical skills and their ability for abstraction and model design. Besides technical and methodical knowledge, so-called soft skills/key qualifications are also essentially important. But there exist a lot of deficits in the general engineering education, as shown by a study from VDI (Association of German engineers). In this study, several companies were asked about deficits and reasons for detachment during the probation period: 55,1% of the companies criticize the social competence of entrants, 47% complain about personal competence and only 13,1% of the companies mention the professional competences as a deficit of entrants. The main reason for detachment is the disability of the entrants to transfer the theoretical knowledge into practice, furthermore the entrants' overestimation of their own capabilities as well as the want of social behaviour.

With the aim to improve this situation of entrants in companies, the main requirement for the engineering education is the improvement of the key competences during the education.

Engineers have to be "team players", they have to be skilled in technical know-how and business management and they have to capable of reaching decisions and implement them. In order to meet these requirements in the university education, KaLeP (Karlsruhe Education Model for Product Development) was developed at the IPEK (Institute for Product Development, University Karlsruhe).

It is important to emphasize that a problem of need for „closing space" between engineer education and practice requests is not just evident in immediate surrounding (former Yugoslavian republics), but solution of this problem represents challenge to most of big developed countries and their mechanical engineers education system. The basic reason why this space appeared is lack of „rational"and „detailed". That is why modern approach to education of mechanical engineers has to assure capabilities: *Conceive, design, implement and operate.*

3. KaLeP MODEL OF EDUCATION

KaLeP is general concept oriented to real product development process in industry, based on construction theory in education, created to improve developing engineer's competence in product development. KaLeP method goal is to inform participants in complex product development environment (that are currently in the education process), about the aspects of real working environment and teaches them the best possible basis for complex challenges development in further professional career. Also, mentioned model is enabling a work on concrete project's tasks, in work's conditions which are very similar to real, industry's requirements. The project conceived in that way – performing according to in advance predicted steps, which has presented by plan, with predicted terms for lectures, workshops, presentations and milestones (reviews). The plan has predicted lecture's performing, by nominated professors, from their parental faculty, according to their educational plan and program. Also, the plan has predicted, in addition, adequate workshops, guided by assistants and presentations performed in same time, by usage modern video-equipment, which enables establishment video-conference and enables participation for all participants in process, under same conditions.

THE KARLSRUHE EDUCATION MODEL KaLeP		
Education	Environment	Key qualification
Lecture **Exercise course** Project work	**Creation of realistic Environment**	**Integrated Project work**

Figure2. KaLeP model of education

Figure3. IP projects - examples

Institute of product development IPEK has many years of tradition in crating projects based on KaLeP method. Also, their project results have utilized in concrete purpose.

4. THE RESULTS OF SUCCESSFUL COORDINATION PRACTICE

In order to reach an innovative idea for human resource management in process of product development and to make improvement in evaluation of engineer profile competences (as team members) an real experiment had placed in the base of joint project of collaboration between Mechanical faculty in Niš (Serbia) and Mechanical faculty in Karslruhe (Germany). That project included 4 teams, 2 from Serbia and 2 from Germany, a combination of unique-culture teems with cross-culture cooperation, with common aim – development of new product for German's industry demands. That fact was specific of this project. The manner for target realisation was unique, an education model KaLeP.

But, this experiment was a first time that two different faculties have involved in it. Also, KaLeP model was an aim of knowledge transfer between Mechanical faculties Karlsruhe and Niš. In that circumstances, in order to control and monitor project, it was necessary to set same limited conditions for realization. That was also challenge and that was base for comparison of project results. Basic education plans and programs on this faculties are very different, so basic students knowledge was very different, as their background in whole. This unique cooperation is maintained by coordination during project, at the start of the project until first turning point. Also, goal was not only education and gaining experience through work in virtual teams, but development task based on KaLeP method, in two different work and living conditions and output of this process is working prototype for industry needs.

4.1 How to create a functional team?

Size and complexity of most developmental projects nowadays require team work rather than individual, so the necessity of team work in product development is generally accepted. The results of team work depend on many factors: team members' qualification, good structure of product development process and methods for supporting product development process. Team must focus its attention to different working styles, problem solving styles of all team members. Importance and role of team and team work in product development process is very significant segment of this work.

Design problems, by usage teams, are individual also, in understanding, generating, evaluating and making decisions, at the same time. But, there are many important differences, which should be clarified and solved. In the first place, social aspects of team work which are growing up in every social activity. In the second place, every team member has different problem's understanding, different alternatives for problem solving, and different knowledge for problem evaluating. The first and second thing is good and the bad, at the same time; it is a place for many solutions and much more confusion. The modern, design problem demands design team – a relative small number of people, with complementary skills, which is integrated in common purpose, common target acquirement and common access, in amount which they can take care of each other. But an effective team is much more than that.

Within promotion of team and team work value in product development process, where team composition of players is vital value of project success, it is necessary to use participant competence evaluation methods, at next levels: professional competence, methodological competence, sociological competence, elaboration possibility creative potential.

As a result, different types of character tests are used and they allow self-assessment of ones own competences based on obtained results. Such are MBTI test, especially Balbin test, which gave practical results of application when forming teams of students. For example, Balbin suggest 9 different behaviours required for team functionality regardless the skills: Organizer, Motivator, A person who «encourages», Soldier, Collector, Listener, Finisher, Specialist and Evaluator.

In order for mentioned roles to be applied, team has to identify members who would actively and with responsibility assume roles during the project. The role assignment has to be made through individual evaluation, discussion, management decision making and simulation of team creation. The key is in roles being assigned according to skills, with periodical review of team progress and execution.

Developmental teams should comprise the same number of different types of persons, with variations when equalizing average team competences, in order to have homogeneous group which in optimal way supports dynamic effect. It could be very exciting to be a member of a productive team, but it could be frustrating to work in a team that does not function very well.

One of commonly used procedures for evaluation of profile competences is shown in Figure 5.

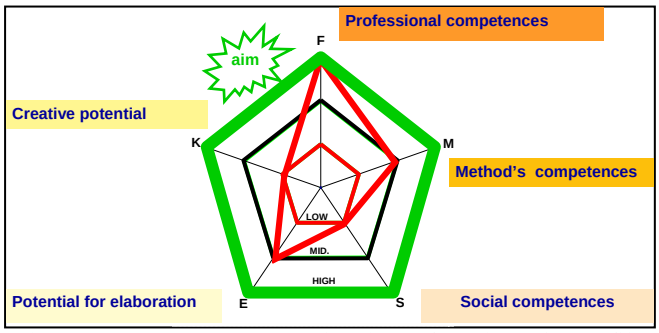

Figure4. Competences evaluation of engineer's profile

If evaluations are reduced to simple measurement of work results, in form of reports, presentations and physical inspections of project products, we cannot be certain that students have developed competences which were intended to be developed.

In the following is showed an innovative model of evaluation, through collecting students' opinions and feedback information. The reason for that is a result of integrated learning which gives capability to students to make assessment of their own work and outside work, because main part of their work isn't monitored (controlled) from teacher's side, as teachers aren't incorporated in their work completely.

System for assessment consists of next assessing elements:

- Project targets (aims, goals)
- Capability of expressing (conceiving attitude),
- Giving of feedback information about another's contribution through suggestion of appreciation,
- Capabilities for evaluation (assessment) of work quality and work quantity for all members,
- Expressing reflection on complete project

4.2 Student's project

In given circumstances, four undergraduate student teams, two from IPEK, TU Karlsruhe and two from Mechanical Engineering Faculty, University of Niš (MFN) were involved in the product development project defined by German company Kärcher. Teams were formed in accordance with previously described model for evaluation of development engineer's competences. All of the student teams had the same development task, so their performance could be measured during the project lifetime and in that way evaluate the model for evaluation of development engineer's competences.

Student teams were competing between themselves as competition foster the team work.

As the development task, Kärcher defined that students should develop device for sterilisation of water by UV (Ultra Violet) radiation. The project development task was based on idea that was introduced by TU Karslruhe student team during previous project. The idea is that passive circulation of water in the tank is achieved by heating of water trough waste heat emission of UV emission element. It is observed that only 10% of energy input to UV emission element is transformed to UV radiation, the remaining energy is transformed to heat.

According to the development task defined, student teams should:

1. elaborate the basic idea, expand it if possible, and develop device for sterilization of water by UV radiation;
2. develop device which doesn't posses any active elements e.g. the flow of water around UV sterilization element must be passive;
3. develop device which after the filtration process provide water which is acceptable for drinking according to the microbiological standards[1];
4. manufacture the prototype of the device and validate it in operating conditions;
5. chemically treat the intake water is a plus, but not obligatory;

During the four months long work on the project, student teams from Niš developed two innovative devices for pathogen filtration of the water. After market and their own development capabilities research, student teams defined the profile of new products, expanded the basic project idea trough several product concepts, evaluated those concepts and design the best evaluated. As the last phase of the project, prototypes were made and validated according to the project task. Both teams came to innovative approaches for expanding of given development task idea trough usage of modern methods in industrial product development.

One of student teams (team WAFIPO - WAter FIltering PrOject) came to idea to speed up the passive circulation of water in the filter tank (and thus lower the filtration time or increase the capacity of the filter) by heating the lover sections of the tank. They defined product that will be

Figure 5. Student team WAFIPO prototype

used in equatorial area, which is the most endangered region concerning the supplies of drinking water.

Second student team (CFS- Constructors from South) came to idea to increase the passive flow velocity in the tank by under pressure. If above the free surface of the water is under pressure the water will boil at temperature lower than 100 ^{0}C. If under pressure is greater than 0, 9 bar the water will boil at room temperature. Boiling of water has two effects:

- The flow velocity around UV emission element is vastly improved, and
- Oxygen from the water is removed so most of the pathogens are killed because they etc. cannot survive the lack of oxygen in a period longer than 15 min.

They defined the product profile with the goal of removing the usage of chlorine in city distribution networks. In modern distribution networks chlorine is used in the water treatment process for sterilization and prevention of pathogens after grow during the transport to consumer.

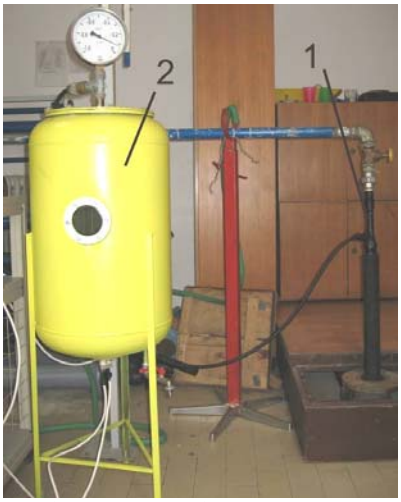

Figure 6. Student team CFS prototype

Table 1. Results of water microbiological testing

		Inlet values, before filtration	After 1h. filt.	After 5h in prot. 12h. in refrig.
Total count vital bacteria	TCV	142/1 ml	0	0
Total coli forms	TC	161/100ml E-coli	0	0
Faecal coli forms	FC	161/100ml E-coli	0	0
Faecal streptococcus	SF	0	0	0
Clostridium sp	SSA	76/100ml	0	0
Proteus sp	PV	0	0	0
Pseudomonas sp	PA	0	0	0

Water was tested after the filtration process to ensure that it is safe for drinking if she stays in the tank. Table 1 shows the results which clearly show that water is safe for drinking after the filtration process is finished and it is not used instantly. In that way it is proven that chlorine used in water treatment can be removed in water treatment process.

5. CONCLUSIONS

With the help of many years experience that the Institute of Product Development of the University of Karlsruhe has in implementing the education project Integrated Product Development (IPD) and the continuous improvement of KaLeP, it was achieved to meet today's requirements for a successful engineer education. Evaluation results and interviews with graduates show clearly that the KaLeP approach improves systematically the key qualification for engineers. In the meantime, the education model of the IPD was transferred to the special fields – East Europe's countries. It demonstrates that the integration of aimed training of soft skills in a practice environment in combination with the university education with long tradition of is a very successful model.

This model demonstrated results through coordination and management of common cooperative innovative project, which has performed by student teams from Mechanical Faculties in Niš and Karslruhe. The success of project realisation is result of good team member selection, good project performing and project coordination. Students demonstrated strong motivation and achievement orientation. Their presence on the lectures was over 95%, so in some critical phases of the project they demonstrated the behaviour that vastly exceeded demands of classical education model. Although the involvement in this project is based on a hard work, the knowledge and experience gained in this way can be directly applied in a practical work. That makes great benefit for future development engineers once they graduate.

Result of student's development project, are two products that could be instantly implemented in the manufacturing program of the company that has sponsored the project. Student from Serbia performed similarly to the German student teams. By that, the quality and the effectiveness of the project and new model for evaluation of development engineer's competences are proven in the best possible way. This joint student's project could be a good example for future work, not only as an example of knowledge transfer, also as example for effective team work with results - practicable products.

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