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RAPID PROTOTYPING SERVICE MODEL BY THE CDIO EDUCATIONAL FRAMEWORK

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Abstract: *This paper produces a plan how Rapid Prototyping Services RPS to (external) enterprises and businesses can be accomplished by universities which use the CDIO educational framework in their undergraduate engineering education.*
The CDIO Syllabus summarizes formally a set of knowledge, skills, and attitudes that alumni, industry, and academia desire in a future generation of young engineers. The CDIO Syllabus can be utilized to define new educational initiatives, and it can be employed as the basis for a rigorous assessment process, such as is required by ABET (www.abet.org).
Some technical universities supply RPS to external enterprises and businesses. This paper shows how this service process can be included to stages of CDIO educational process. Through the CDIO educational framework the engineering students are able not only to adopt the techniques of rapid prototyping engineering but also fundamentals of engineering service processes and business to business service sales.
Key words: *CDIO Syllabus, Rapid Prototyping Service RPS, External service, team, business-to-business*

1. STRUCTURE OF THE CDIO SYLLABUS

Graduating engineers should appreciate engineering process, be able to contribute to the development of engineering products, and do so while working in engineering organizations. That is why graduating engineers should be able to conceive-design-implement-operate (CDIO) complex value-added engineering systems in a modern team-based environment. The CDIO framework model is created to build blocks of knowledge, skills, and attitudes, given in Figure 1.

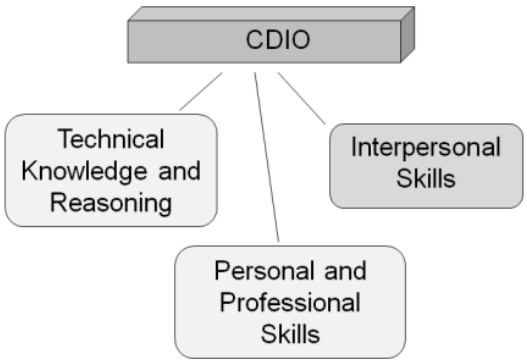

Fig. 1. Blocks of knowledge, skills and attitudes necessary to Conceive, Design, Implement, and Operate Systems (CDIO) in the Enterprise and Societal Context (E. F. Crawley, 2001)

In the CDIO Syllabus (Conceive, Design, Implement, and Operate), the blocks of knowledge, skills, and attitudes are further divided into smaller hierarchic parts. These are developed within External and Societal context (ESC) and the Enterprise and Business Context (EBC). These contexts do not drop in some stages only, but are constantly present within the CDIO learning environment, see Figure 2.

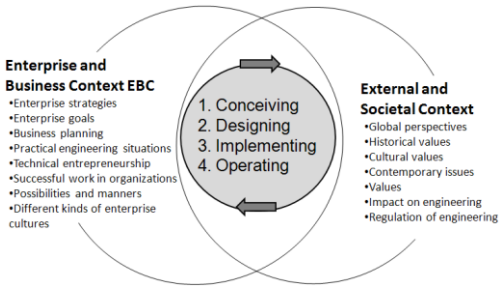

Fig. 2. CDIO Syllabus within the ESC and the EBC

2. PRODUCT INNOVATIONS IN ENTERPRISES

The innovation process in enterprises encompasses several systematic steps, beginning from problem/requirement analysis to idea generation, idea evaluation, project planning, product development, testing and finally product marketing. These represent a simplified innovation process. Special attention is paid to the process of research and development (R&D), which in many cases builds a corner-stone of innovation.

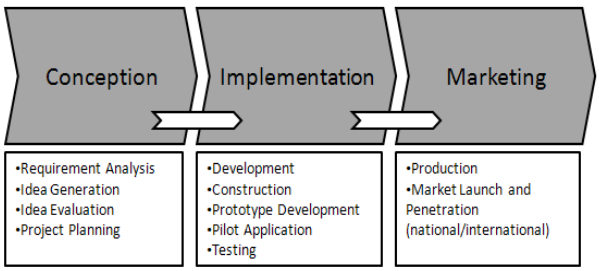

Fig. 3. Three phases of a simplified innovation process (TIM, 2010)

Large firms tend to introduce more "novel" innovations than small and medium-sized enterprises (SMEs). There are also differences across countries. Within Europe, SMEs in France, Luxembourg and Sweden had a significantly higher propensity to introduce new-to-market product innovations than those in Hungary and Poland (OECD, 2009).

3. RAPID PROTOTYPING PERFORMANCE

Although several rapid prototyping techniques exist, all employ technically the same basic five-step process (W. Palm, 1998):

1. Create a CAD model of the design
2. Convert the CAD model to STL format
3. Slice the STL file into thin cross-sectional layers
4. Construct the model one layer atop another
5. Clean and finish the Model

To prototype successfully (L.J. Najjar, 1990), you need to select an appropriate technical RP tool and form a RP team.

The **team** (of experts) should include (a) a domain expert, (b) an information developer, (c) a marketer or planner, (d) a programmer, and (e) a usability representative. Their variety of skills allows the members of the small team to prototype quickly and efficiently a user interface that meets customer needs and development constraints.

Najjar (1990) points out that technically the RP process involves two separate iterating stages: Repeating (1) the "prototype-feedback-improve prototype" cycle and (2) the "actual code-feedback-improve actual code" cycle.

4. RPS BY THE CDIO FRAMEWORK

The elements of the RPS model should include relevant elements from the CDIO syllabus, the RP prototyping techniques as well as the general RP process of experts. To formulate the RPS model logically, we will first arrange the needed elements into groups of objects (nouns) and actions (verbs) and then describe the three processes simultaneously in Figure 4.

The list of objects (nouns) will include the following:

- The RP team (including students and experts)
- The customer and its agents
- The target product and its properties
- The prototype
- The RP technique chosen
- The time schedule and the budget

The list of actions (verbs) will include the following:

- Discussing the task and choosing the innovation level
- Regulating and adjusting the RP process during work
- Changing, Developing and Iterating the Prototype
- Testing the prototype solutions
- Finishing the best prototype
- Saving the necessary CAD documents
- Consulting and Advising by experts
- Learning to conceive, design, implement and operate the RP process by the students
- Making decisions by the customers

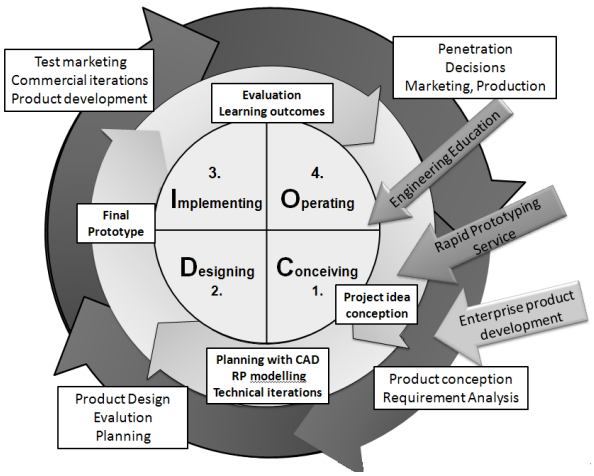

Fig. 4. RPS in relation to CDIO Engineering Education and Enterprise product development function

It is important to include students to the RPS team to run the service process within the CDIO educational framework. By participating actively, the engineering students are able not only to adopt the techniques of rapid prototyping engineering but also fundamentals of engineering service processes and business to business service sales. Our suggestion is that the RP team, proper for CDIO education framework within a university, would include (a) skilled lecturer, (b) small group of students, (c) programmer, (d) enterprise representatives. Contemporary experts may be used when needed.

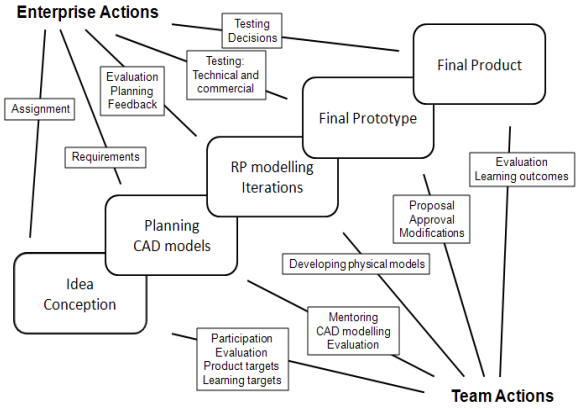

Fig. 5. RPS Model and Actions. The model includes four elements: The team, the system, the product and the enterprise

5. CONCLUSIONS

This article shortly describes together the CDIO Engineering Education, the RPS activities and the Enterprise product development functions. This is done in order to produce a plan how Rapid Prototyping Services RPS to (external) enterprises and businesses can be accomplished by universities which use the CDIO educational framework in their undergraduate engineering education. We have produced a simple model for the purpose and presented the model above. The steps and actions of the model are presented in Figure 5. Rapid prototyping can be seen as a modern tool not only for developing products, but also as a facilitating process to enable CDIO cognitive learning processes (A.D. Kolb, 1985) of future engineers and company representatives within rapid prototyping teams.

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