WCLTA 2013

Competence Driven Methodology For Curriculum Development Based On Requirement Engineering

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Abstract

Developing a study program always leads to target conflicts of the different stakeholders industry, students, state resp. politics and universities. Unfortunately today a lot of new study courses are developed by mixing existing courses (e.g. industrial and commercial engineering or commercial information technology) or adjusting existing courses (e.g. technology of sustainable energy formed from mechanical and process engineering or environmental engineering formed from civil engineering). In most cases universities try to keep their well-known infrastructure and lecture courses based on the expertise of the current staff while using attractive short term hypes to make their course offer more attractive. Since this leads to frustration for the students expecting different content and may not fulfil the expectations from industry; we developed a new approach focussed on skills and competences in RiFLE project. This paper gives an overview how this approach works and how it was used while developing a master program (MSc in Rail Freight and Logistics).

1. Introduction

Developing a new program means bringing in line the expectations of the stakeholders industry, politics, students and universities. Industry asks for skilled people having a set of defined competencies. Students are interested to acquire these competencies to have good job opportunities, while politicians are interested to provide those graduates to ensure people having jobs and may provide a related funding to universities. Universities and their staff now have to provide appropriate courses, while ensuring their current facilities and courses are utilized in an optimal
way. Beside this a very important - maybe the most important - function of the teaching staff resp. professors is to ensure that a study program is more than a job training imparting skills used in today’s jobs but also imparting methodologies to solve unknown problems to face challenges of the future.

It is common sense that well known degrees indicates a set of qualifications like several competencies, skills and experiences. So employers have organised their recruiting department in a way, that operating departments announce the demand for a holder of a special degree. This makes expected qualifications and degree synonymous. In the same manner a lecture course and the taught content, skills and competencies are used synonymous in universities (e.g. Fundamentals of Mathematics contains a set of topic taught in one semester). So developing a new program means breaking this images and collecting the expectations from industry without fixing the type of teaching or the lecture course. This means focussing on the competencies students acquire during study courses and use the methods of requirements engineering to find out which competencies are requested by potential employers today and which competencies will be needed in future based on estimations of experts from the related area.

Second step is needed to ensure the study program is not just a vocational training but university studies.

2. Terms

![Diagram](image)

To ensure a valid procedure we choose to use a scheme of the bologna way of organizing a study course shown in Figure 1(a). It shows that other parties, e.g. employer, companies or costumers have a picture of the competencies an owner of a diploma has. This is what is expected by common sense. So having a specific diploma indicates having specific competencies. Therefore curriculum development should focus on the competence a graduate gain during a course. The study course is organized in so called modules that may contain seminars, lectures and practical work like labs etc. and provides information, skills and practical experiences to allow students acquiring competencies. Every module contains some assessment and allows earning credit points (ECTS credits). Some modules depend on others modules, some modules exclude others modules etc. At the end of the day most study programs are organized in a way students have to earn a predefined amount of credits in a given set of modules to receive a diploma. Since this wouldn’t be changed in short term, the challenge is to identify the competencies students have to acquire and organise them in modules (lecture courses, lab courses, seminars ...).

Figure 1(b) shows the main terms used to describe the way to get competencies and how they are used in RiFLE project: Information or data is provided by books or other media; it represents the written facts about a topic. Information is provided in books or spoken in lectures. Knowledge is information known by a human. The aim of a lecture or any other course is to produce knowledge by providing information in a suitable way. Practical Experience is learning methods by solving problems (learning by doing) in today's courses practical experience is provided by labs and internships. A skill is the ability for using the knowledge in a practical way. This means having the knowledge about a topic and be able to use the actual methods to solve today’s problems. Competence or expertise is the ability to use skills in a way that allows solving new kind of problems, adapt the current methods and develop new methods. Today’s courses should be organized in a way focussed on imparting competence to the students.

3. Basic approach

Following the described postulations means focussing on the competencies students acquire during study courses and use the methods of requirements engineering to find out which competencies are requested by potential
employers today and which competencies will be needed in future base on estimation of experts. Therefore a dialog with experts and employers from industry and academic society was initiated (Figure 2).

3.1. Requirements engineering (gather requirements)

The approach follows the method of requirements engineering, where the requirements are gathered by asking experts which competencies today railway logistic experts shall have. The requirements were collected by several surveys (see [1], [2] or project web page http://www.rifle-project.eu). As an outcome of requirements engineering it is possible to measure the grade of fulfilment to ensure the resulting study program meets the needs of all stakeholders; see paragraph Requirements Engineering (Measure grade of fulfilment).

3.2. Curriculum engineering

Before starting modelling a curriculum the inner structure of the elements and their relations has to be defined. In our approach we defined modules provide information, skills and practical experiences to produce a specific outcome (competence). To ensure students can attend a module successfully modules may require competencies to enter them (see Figure 3(a)). This leads to the fact modules may depend on each other as seen in Figure 1(a).

After definition of sub modules providing requested competencies assembling of modules can be done. A Module provides the sum of ECTS credit points, skills, practical experiences, knowledge and competencies of all its sub modules. Combining sub modules in modules helps giving structure to the course (see Figure 4(a)).
After definition of modules modelling the course / curriculum can be done. Since a course is just a number of modules a sum of output coming competencies and of required competencies can be calculated (see Figure 4(b)). A challenge in developing a master program is facing the fact a master program has a very heterogeneous target group and a lot of different degrees of applicants have to be proved as valid conditions for entering the course (Figure 5(a)).

As shown in Figure 5(a) there is a need to conform entry competencies, this leads to the fact, if the result shall be graduates with a required set of competencies and the applicants for the program come from different courses, bringing in different competencies, the master program has to be flexible in a way providing different ways to fill the gap between the entry competencies and the required outcome. In RiFLE project we faced the fact, that railways are technical systems and logistics is usually a part of business studies. Therefore we wanted to allow students from different backgrounds like mechanical engineering, civil engineering and business studies to start our master course. This leads to the need of allowing personalized routes through the course.

As seen in Figure 5(b) we introduced elective modules, where a module can be chosen from a given set of offers. Pending on the personal entry competencies (indicated by a bachelor diploma) some of these modules may become mandatory and there may be no individual choice for some students. Defining the personal mandatory modules is part of the permission process.

Since the outcome (e.g. credit points, competencies) can be summed up easily it is possible to set up a database to aid the engineering of curriculum. As seen in Figure 6(a) the requirements from industry and experts can be modelled as required competencies. Since competencies may cover or require other competencies this requirements result in a competencies tree (left side of mentioned figure). The modules modelled in the curriculum have competencies as outcome. So this is a good point to bring together planned curriculum and determined requirements. This approach mirrors exactly the approach of Bologna process not to rely on predefined topics resp. disciplines with prepared lectures, but developing programs based on the competencies to be imparted.

3.3. Requirements engineering (measure grade of fulfilment)

At the end of the day requirements engineering is done for measuring the grade of fulfilment to check if requirements are met. Following our approach this can be done by matching required and provided competencies.
Several competence trees indicating expectations on several degrees can be seen as columns of a Boolean values matrix, where true or checked indicates the competence in this row is required. As a second step this required competencies are matched with the provided competencies by a second matrix of Boolean values, where the modules are the columns and the true or checked indicates this competence is provided by the module in this column. During modelling the curriculum this second matrix allows identifying modules that may provide competencies that are not covered yet. By activating and deactivating the modules different scenarios can be checked. While modelling a master course curriculum the different entry bachelor degrees are modelled as modules to allow a full sum for the whole master degree including also the earlier education (see Figure 6(b)). This double match procedure allows calculating the grade of fulfilment for different degrees using different scenarios for different types of entering students.

4. Conclusion

Following the Bologna way during planning or modelling a curriculum means focussing on competencies not on predefined disciplines and prepared lectures. This causes a high effort for gathering the requirements resp. required competencies from industry and other experts by doing surveys, workshops etc. After compiling this set of competencies has to be cleaned up to ensure the resulting program is not only a vocational training but an academic study. Based on this spadework it is possible to model a curriculum meeting the requirements of all stakeholders. In reality many of the available lectures, disciplines and modules match the requirements, so not everything need to be redeveloped or newly developed and can be used in the new program, but by making the context transparent, it is possible to find and resolve gaps.

References