2nd International CDIO Conference
Linköping University
Linköping, Sweden
June 13 to 14, 2006

INTEGRATED PROGRAM DESCRIPTIONS – A TOOL FOR COMMUNICATING GOALS AND DESIGN OF CDIO PROGRAMS

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ABSTRACT

The CDIO syllabus provides a generic platform for writing program goal statements. Specifically, intended learning outcomes for personal and professional skills and attitudes such as communication, teamwork and ethics can be stated by combining a topic from the CDIO syllabus with an appropriate cognitive verb that reflects the desired proficiency. However, a complete program goal statement must also include goals for mathematical, scientific and technical knowledge. Moreover, while a "pure" goal statement may be suitable for and support discussions with external stakeholders such as industry leaders who are not involved in the program design as such, deliberations with internal stakeholders such as faculty and students often need to address both the goals for the program and they way in which they are realized – the program design.

In response to these needs, the paper presents a framework which brings together the goals and the design of the program. This achieved by combining the CDIO syllabus and the CDIO curriculum design tools, in a framework that also includes the statement of program-specific goals for disciplinary knowledge. We call this framework integrated program descriptions. In the paper, the contents of these components and the process of implementing them at Chalmers and KTH are discussed. The KTH case involves the CDIO-based Vehicle Engineering program. The Chalmers application spans about 70 engineering programs, both CDIO-based and non-CDIO-based. Benefits and challenges are discussed.

INTRODUCTION

The importance of clear and complete program goals for undergraduate engineering education has recently been emphasized in political statements such as the Bologna Declaration of the European Union [1], in requirements from accreditation bodies such as ABET in the USA [2] and the Engineering Council in the UK [3], and in national program evaluations such as the evaluation of Swedish ”civilingenjör” engineering degree programs undertaken by the Swedish National Agency for Higher Education [4].

In this context, the program designer faces the challenge to explicitly show how the program design meets the program goals, and this has to be reflected all the way down to the units of instruction, referred to as courses in this paper. Traditionally, the development of the content of a particular course was delegated to the faculty responsible for the course, and at the best the details of the content was discussed in terms of pre-requisites regarding technical knowledge and skills. Many faculty also have limited knowledge of the goals of the program that they teach in as well as of the content of others courses than their own. Typically they form their opinions based on the content of the corresponding courses from the time of their own engineering education. Overall this leads to uncertainties concerning the value of the contribution to the program goals from a specific course, and if the program goals as required by stakeholders are met.

The CDIO syllabus [5] provides a generic platform for writing program goal statements. Specifically, intended learning outcomes for personal and professional skills and attitudes such as communication, teamwork and ethics can be stated by combining a topic from the CDIO syllabus with an appropriate cognitive verb that reflects the desired proficiency. In addition to that, a complete program goal statement must also include goals for learning of mathematics, science and technical knowledge. Moreover, the program description must serve the needs of two different stakeholder groups. A purely outcomes-based goal statement would be suitable for discussions with *external* stakeholders such as industry leaders, who are not necessarily interested in how these outcomes are attained. However, *internal* stakeholders, such as faculty and students, are also involved in the program design and execution. They need to address <u>both</u> the goals for the program and the way in which they are realized – the program design.

In response to these needs, this paper presents an approach for program development that brings together the goals and the design of the program into a coherent information package. This is achieved by combining the CDIO syllabus and the CDIO curriculum design tools in a framework that also addresses the statement of program-specific goals for disciplinary knowledge. We call this framework integrated program descriptions.

An integrated program description (IPD) describes in detail the purpose, goals, basic idea, content and structure of an educational program and the connection between these. An IPD also identifies core competencies to be developed, defines the courses that constitute the program, describes in which course specific learning outcomes are addressed, outlines planned learning sequences for integrated learning outcomes, and defines the course plan for each course. The explicit and detailed description of the program allows internal and external stakeholders to discuss and evaluate the program in considerable depth.

The paper is structured such that the next chapter gives examples of the political and accreditation demands which are the context for this work. This is followed by a description of the components of an integrated program description. Thereafter, the application of the concept at the Royal Institute of Technology (KTH) and Chalmers University of Technology is illustrated. Finally, benefits and challenges and conclusions are discussed.

PRE-CONDITIONS AND RELATED WORK

There is a strong movement towards a higher degree of explicitness regarding learning outcomes in higher education. This applies to both program and individual course level, and comprises both subject-specific learning outcomes and those others that are termed in many ways: generic skills, transferable skills, graduate capabilities, generic competences, etc.

Across Europe, the *Bologna Declaration* [1], which aims at the establishment of a European area of higher education, is a strong driver for explicitness in order to facilitate harmonization, student mobility and quality assurance. Its' first action lines concern the adoption of a system of "easily readable and comparable degrees" based on two main cycles. An important part of the process has been the establishment of the *Dublin Descriptors* [6], which define outcomes for Bachelors, Masters, and Doctoral programs, with respect to five basic aspects: knowledge, application of knowledge for problem-solving, integration of knowledge for making judgments, communication and life-long learning skills. The Dublin Descriptors are intended to be applicable to degrees within any discipline, which makes them rather general. Consequently, the Dublin descriptors have been criticized for being too abstract to guide program and course development. Therefore, national agencies have tended to use the Dublin descriptors as a baseline for the development of more specific professional degree learning outcomes, rather than as-is.

One alternative is to refine the Dublin descriptors while maintaining their discipline-independency. This strategy has been pursued by three Dutch technical universities who have developed the Dublin descriptors into specific criteria for their bachelor and master programs [7]. Their approach uses seven dimensions of competences: a graduate should have competence in one or more scientific disciplines, competence in doing research, competence in designing, have a scientific approach, possesses basic intellectual skills, be competent in co-operating and communicating, and be able to take into account of the temporal and social context. This work is valuable, with possible application to engineering education. Especially the detailed analysis of the progression between the Bachelors' and Masters' levels makes it a useful contribution. However, as compared to the CDIO approach, the only engineering competence considered is "designing" (which they consider to be a skill which is relevant for all professions, including law as well as engineering), a much narrower view on engineering than the conceive-design-implement-operate context implies.

Another approach is to add learning outcomes relevant for the professional field in question. For example, the Swedish government has published a new *Degree Ordinance* for all education programs (circulated for consideration in April 2006, final decision pending) [8]. The Degree Ordinance states new goals for both the 3-year "Högskoleingenjör" degree and for the 5-year "civilingenjör" degree. The outcomes in the Degree Ordinance contain the Dublin Descriptors for the respective levels, complemented with a number of learning outcomes relevant for professional engineering practice. However, these added outcomes reflect engineering as a whole, and are not specialized onto the sub-disciplines of engineering, such as chemical or mechanical engineering. Thus, they remain a baseline from which a program must derive its particular goals. An approach to include also subject-specific learning outcomes is developed in the *Tuning project* [9] which identifies "points of reference" for generic competences of first and second cycle graduates, as well as subject-specific competences formulated for selected subject areas, among them physics and chemistry, but not engineering. The description of competences is intended for curriculum design and evaluation, and to provide a common language for describing what curricula are aiming at. The Tuning approach is based on an analysis of the need for a program, a description of its profile, learning outcomes phrased in terms of competence, the use of the ECTS credit system, and approaches to teaching, learning and assessment. However, the Tuning model does not include specific development tools such as the CDIO syllabus, and has so far not published results from comparisons of engineering programs.

Other national initiatives have emphasized the role of explicitness for the accreditation of educational programs. Examples include the US *ABET Engineering Accreditation Criteria* [2] which specifies, among other things, that a program must have detailed published learning outcomes and a stakeholder needs-driven process to determined and evaluate the learning outcomes. The program outcomes are specified in eleven categories. In the UK, the Engineering Council publishes the accreditation standards called *UK-SPEC* [3]. Output standards are expressed as a list of required learning outcomes, both general and specific.

These examples show that learning outcomes that are increasingly used for purposes of harmonization or accreditation. As such, they are *global* learning outcomes that programs need to relate to. However, they are rarely specific enough to guide the design and implementation of an engineering program, and they lack the level of detail that is necessary to help bridge the gap between program and course level. A comparison between the eleven ABET outcomes and the CDIO Syllabus was made in the CDIO Syllabus Report [5] and showed that the CDIO Syllabus covered and went beyond the ABET outcomes, and the UK-SPEC is less detailed and also focuses more narrowly on the design phase of the product and system lifecycle. While the new Swedish Degree Ordinance is more detailed than the previous one, it is still less detailed than the CDIO Syllabus. Some learning outcomes are expressed in long sentences grasping a large number of different aspects, thus making it difficult to use for guiding course development. Moreover, it does not include any subject-specific requirements for fields such as mechanical engineering, so each program will still have to complete the Degree Ordinance requirements with its own goals. The Tuning model takes a step in this direction, by addressing also subject-specific knowledge and skills. However, it has so far not been applied to engineering education, nor to the (re)design of programs. This activity also requires the provision of tools for stating goals and for connecting the learning outcomes to the curriculum, as included in the CDIO toolbox.

In this paper, we present a framework, called integrated program descriptions, that connects these aspects together, and provides support for the entire program development process, from identifying stakeholder needs to course design.

INTEGRATED PROGRAM DESCRIPTIONS

An integrated program description (IPD) describes the goals, content and structure of an educational program, as well as how these are connected. The intent is to provide the program chair and other key stakeholders involved in the program design process with a set of tools that can facilitate their design process. It also deliberately promotes a design process which emphasizes high-level considerations such as setting goals and developing the program idea. This facilitates the alignment of the goals and content of the program with actual stakeholder needs, and may point out necessary major changes which can be very difficult to motivate and implement when applying the more common practice of program (re)design to modifying an existing program plan. An integrated program description contains six basic components:

The ***program purpose*** is a high-level statement of why the program exists, which defines the overall purpose of the program, including its context and the future professional tasks and roles of its graduates. The program purpose at least defines the particular field that the program addresses (electrical, vehicle etc engineering), the relevant lifecycle phases (conceive, design, implement …) and may imply a specific focus. For example, the program purpose of the Vehicle Engineering program at KTH states that

> *"The discipline of Vehicle Engineering includes aircraft, spacecraft, sea vessels, ground and track vehicles, and systems including such. The Vehicle Engineering program aims at giving the students knowledge, skills and attitudes required to conceive, design, implement and operate such vehicles and systems. The program also prepares the students for work in other fields where knowledge of applied mechanics and systems engineering is of importance, and for graduate studies."*

The ***program goals*** define the knowledge, skills and attributes that the graduates are expected to have developed upon graduation. The program goals can be described as a concretization of the program purpose into a set of assessable learning outcomes. For a CDIO program, the starting point is likely the CDIO Syllabus [5]. However, items in the CDIO Syllabus need to be developed into learning outcomes by connected them to appropriate cognitive verbs, goals for disciplinary knowledge need to be stated and perhaps other adaptations made as well.

The ***program idea*** describes how the program is designed in order to meet its goals. It states the main principles and considerations that underlie the program design. Examples of (elements of) program ideas can be that the program has a stated aim to fulfil the CDIO Standards, or that it emphasizes a particular approach to mathematics, or that it is based on problem-based learning (PBL), has a high number of laboratory experiences or other some other main characteristics of the program.

The ***program plan*** is the formal specification of what courses are included in the curriculum, their credits and placement in the curriculum

The ***program design matrix*** connects the goals of the program with its courses so that it is clear in which course each learning outcome is addressed. The program design matrix also shows the planned learning sequences (or development routes) for learning outcomes which are developed through integrated learning experiences throughout the curriculum, typically generic competences such as communication skills.

Finally, ***course plans*** define the purpose, goals and content of each of the courses in the program, and include a statement that explains the role of the course in the program, and links it to the program goals

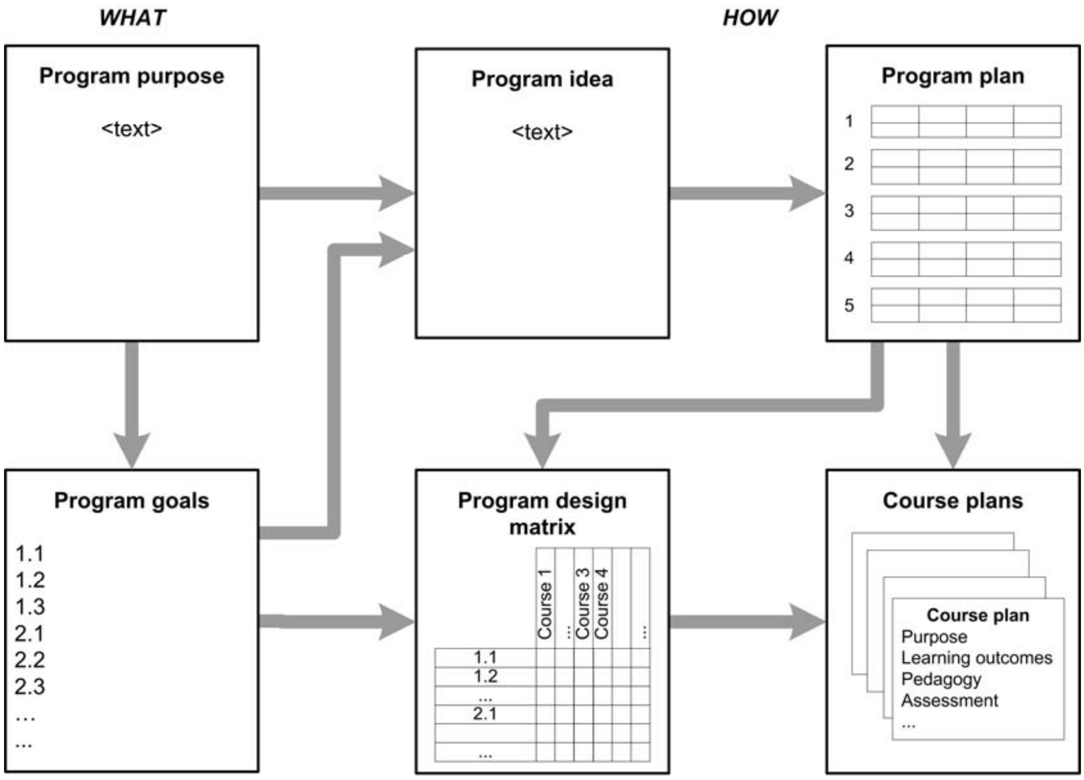

Figure 1: Integrated program description – components

Figure 1 shows the relationships between the components. A program design process that is aligned with the contents of an integrated program description typically starts with the statement of the program purpose, followed by the development and validation of the program goals. The next step is to formulate the program idea, i.e. the fundamental principles and considerations that underlie the program design. The program plan then implements the program idea, by defining the included courses, their credits and placement in the curriculum. The role of the program design matrix is then to systematically interconnect the program goals with the courses, assuring that no program goal is neglected and that there is a thought-through learning progression in the program. Finally, the course plans are developed, by refining the program goals assigned to the course, selecting pedagogical and assessment approaches and so on.

This sequence should not be enforced too strictly. It is important that the program design process allows for iterations, and makes several passes through the components. In particular, the assignment of goals for learning of generic skills needs to be done in a combined top-down and bottom-up dialogue-rich fashion between the program chair and the involved faculty, in order to achieve commitment and to transfer ownership for such goals.

APPLICATIONS

The concept of integrated program descriptions is being implemented at the Royal Institute of Technology (KTH) and Chalmers University of Technology, both in Sweden. Common to these implementations is that the most of the programs are 5-year ”civilingenjör” programs which consist of a compulsory component essentially contained within the bachelor part of the program followed by a range of master programs, from which the students selects one. For these cases, an integrated program description may be organized as shown in Figure 2, i.e. as a report with an 8-12 page main part. Thus, the essential information in an integrated program description can be captured in a relatively compact and accessible form. Certainly, other formats are possible as well, including interlinked web pages.

Cover page	(1 p)
Abstract	(1 p)
Preface	(1 p)
Table of contents	(1 p)
1 Introduction	(1-2 pp)
Description of the program's background, context, purpose, pre-requisites, degree specification and outline of program description	
2 Program goals	(1-2 pp)
Statement of the program's goals in terms of assessable intended learning outcomes, structured according to the CDIO syllabus	
4 Program design	(5-8 pp)
Description of the program idea: how is the program designed to meet its goals?	
Specification of the program plan: courses including number of credits and placement in curriculum, electives, associated master programs	
Documentation of the connections between the program's goals and its' courses in program design matrix and planned learning sequences/development routes	
References	
Appendix	
A: Course plans for compulsory courses	(20-25 pp)
Course plans for each course including clear and assessable intended learning outcomes. The course goals should include goals for disciplinary knowledge as well as generic skills. The course plan should also include a statement on how the course contributes to the program goals.	
B: Integrated program descriptions for associated master programs	(20-25 pp)
Program description for each of the base programs associated master programs, structured according to the above principles	

Figure 2: Integrated program description (IPD), document structure

The Royal Institute of Technology (KTH)

When the re-design of the Vehicle Engineering program was initiated as part of the CDIO Initiative at KTH an IPD as described above was given high priority. This was mainly motivated by the

- educational system of KTH where many departments contribute to each program in contrast to the program being owned by one department only. In this situation, a particular faculty may teach courses at several programs and feel a lower degree of commitment to each of the programs that they teach in, than to their "subject"
- lack of knowledge among faculty of the contribution to the program goals from other courses than their own
- lack of clear and complete learning outcomes on program as well as course level
- insight among faculty and program management of teaching and learning activities were poorly coordinated

However, it was also considered a necessary planning tool when applying a systematic approach for covering personal, interpersonal and system building skills in an integrated curriculum. Another important aspect was that an IPD will be of large value when the instructor in a course is substituted. The new instructor should then be able to quickly learn the role of the course in the program, and be well aware of also the non-disciplinary learning outcomes expected from the course. The development of the IPD was led by the program chair in cooperation with the program coordinators, pedagogical experts, faculty and students.

VEHICLE ENGINEERING –
INTEGRATED PROGRAM DESCRIPTION

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Introduction

Program goals

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CDIO Syllabus to second level of detail and associated expected proficiencies

Program structure

Program plan (Compulsory Bachelor part)
Explicit disciplinary links between courses
Program design matrix
Development routes for selected general skills
Course content (Bachelor part)
Courses (Elective Masters parts)

Appendix

Complete CDIO Syllabus

Figure 3: Cover and table of contents of the integrated program description for the Vehicle Engineering program at KTH

The first version of the IPD for the Vehicle Engineering program was published in December 2004 [11]. The content and structure of this document is shown in Figure 3.

The primary content of the introduction part is a description of the purpose of the IPD and its relation to program development activities within the CDIO Initiative. This was necessary because most faculty had no earlier experience with this type of document. It was also stated clearly that the major purpose of the document was to describe disciplinary and pedagogical links between courses and which courses that contribute to the student's learning of generic skills. Finally, it was made very clear that the document was not supposed to be static, but subject to continuous change as a result of discussions among stakeholders.

The program goals chapter is a high level statement of the program learning outcomes very much in line with the then-current goals of the Swedish ”civilingenjör” programs as stated by the Swedish Degree Ordinance. These high level goals also emphasise the CDIO context of the education.

The program contents chapter includes the statement that the CDIO Syllabus lists the detailed intended learning outcomes of the Vehicle Engineering program. Learning outcomes on the second level of the Syllabus are listed in the chapter, with the complete syllabus listed in the Appendix. This chapter also describes the expected proficiencies in the topics of the CDIO Syllabus based on the results from a survey carried out within the CDIO Initiative [12].

The next chapter – “program structure” - in the Vehicle Engineering program IPD presents the program plan and the program design matrix, i.e. all courses in the curriculum including credits and placement, and documentation of the connections between courses and the CDIO Syllabus topics. The latter presentation begins with a definition of different types of teaching activities. Here, such were categorized as *Introduce*, *Teach* or *Utilize*, based on intent, time spent, and linkage to learning objectives, assignments and assessment criteria [13].

Table 1: Scale used for classifying teaching activities to address a CDIO topic.

Introduce (I)	Expose the students to a topic. No explicit learning objectives, no major activities such as assignments, exercises or projects, and no assessment is linked to this topic.
Teach (T)	There is an explicit learning objective. Compulsory activities, such as assignments, exercises or projects are specifically linked to this topic. Students are assessed and receive feedback, it may or may not affect grade.
Utilize (U)	Assumes students already have some proficiency in this topic. It is utilized mainly to learn and/or assess other learning objectives.

The program structure chapter also highlights selected important disciplinary links between courses. There are of course numerous more or less explicit links between courses in an engineering education, but these links were given particular consideration during the re-design of the program. These links include courses that share faculty for parts of the courses, or courses that are linked through home assignments and laboratory work. Two examples are the use of software for finite element analysis developed in the course “Finite element method for engineering applications” in structural optimization applications in the course on Optimization, and the strengthening of the learning of transform methods in the course on Differential Equations by immediately applying them in the course on Sound and Vibration.

An excerpt from the program design matrix for the Vehicle Engineering program is shown in Figure 4. Here, the responsibility of each course for introducing, teaching and utilising the topics of the CDIO Syllabus are explicitly stated. This excerpt from the overall matrix shows only the most important (highest proficiency) topics of the CDIO Syllabus at the second or in some cases third level of detail.

	2.1.1. and 2.1.1 Problem Identification, Formulation & Modeling	2.2.2. Survey of Print and Electronic Literature	2.2.3. Experimental Inquiry	2.4. PERSONAL SKILLS AND ATTITUDES	2.5.1. Professional Ethics, ... and Accountability	3.1. TEAMWORK	3.2.3. Written Communication	3.2.4. Electronic/Multimedia Communication	3.2.5. Graphical Communication	3.2.6. Oral Presentation and Interpersonal Communication	3.3. COMMUNICATION IN FOREIGN LANGUAGES: English	4.1. EXTERNAL AND SOCIETAL CONTEXT	4.2. ENTERPRISE AND BUSINESS CONTEXT	4.3. CONCEIVING AND ENGINEERING SYSTEMS	4.4. DESIGNING	4.5. IMPLEMENTING	4.6. OPERATING
YEAR 1																	
Analytical Methods and Linear Algebra I	T			T			U										
Perspectives on Vehicle Engineering	I/T	T	I	T	I	T	T	U	T	T	T	I/T					
Physics	T		T			U	T		U		U						
Analytical Methods and Linear Algebra II	T			T			U										
Mechanics I	T										I/U						
Numerical Methods and Basic Programming	T					U	U		T		I						
YEAR 2																	
Solid Mechanics	T		I			T	U		U		I						
Product Development	T	I		T/U		T	T		U	U	T	T		T	T		
Sound and Vibration	T		I		I	U				U	I	I		T	T	T	T

Figure 4: Excerpt of the program design matrix for the Vehicle Engineering program

3.1 Teamwork

Year 1

4B1052 Perspectives of Vehicle Engineering

The project will have a strategy, a planning and a time plan. In the beginning of the project the students will have a lecture on how to plan a project and how effective teamwork are accomplished. In the time plan different task will be divided between the team members. The students will, in the report, write a short summary on how they experienced the teamwork. T

5A1226 Physics

An assignment in experimental methods is solved in a group of two. Ordinary laboratories occur in the course. U

2D1212 Numerical Methods and Fundamentals of Programming

Programming assignment will be solved in groups; on of the assignment will be presented orally. U

Year 2

4C1010 Solid Mechanics

An assignment that will be solved in groups of four. The instructor, responsible for the course, will organise the groups. U

4F1815 Product development

Students will solve a technical problem, from ideas to realization. T

4B1117 Sound and vibrations

The students build a silencer. U

Figure 5: Development route for CDIO Syllabus topic 3.1 Teamwork.

Then follows the description of selected “development routes” for knowledge and skills that are taught in a number of consecutive courses using an integrated learning strategy. The objective is here to cover both disciplinary and general knowledge and skills, but in the first version only some of the most important generic skills are included. Figure 5 shows a development route for teamwork which is used as an example in [11].

This basically completes the overview description of the program. The final parts of the IPD contain the detailed plans for the courses constituting the program. First the bachelor part of the program, containing primarily courses that are compulsory for all students, is described in considerable detail. Thereafter, the associated master’s parts are described. In the first version of the IPD [11] this is described in much less detail than the bachelor part. The reason for this is primarily that there was a mutual agreement that focus should be on the compulsory courses, where most change could be expected.

It should also be noted that the present version of the IPD does not include all course information, e.g., the detailed disciplinary content, number of student contact hours, and type of assessment (written exam, oral exam etc.). The reason for this is that this information is easily available in the KTH Study Handbook. In the IPD, the courses are entirely described in terms of learning outcomes and coverage of the topics of Chapters 2-4 of the CDIO Syllabus.

Chalmers University of Technology

The introduction of IPD’s at Chalmers includes all of Chalmers’ bachelor and master programs. Thus, the application involves a large number of program, 25 bachelor and 44 master programs across a wide range of engineering domains. Examples include bachelor programs in Mechanical and Computer Engineering as well as master programs in Biotechnology and Fundamental Physics.

The decision to rewrite all program goals at Chalmers was motivated by several external factors. Initially, the main driver was that the 2005 evaluation of Swedish “civilingenjör” programs pointed out that the Chalmers’ program goal statements were too general, too diverse and too poorly linked to the curricula. Moreover, they were criticized for lacking goals for personal, interpersonal and professional skills [4]. In addition, the recent developments in the Bologna process have resulted in a set of learning outcomes that characterize qualifications at bachelor, master and doctoral degree levels, known as the

Dublin descriptors [6]. As stated above, the Swedish Degree Ordinance has been changed to adapt to these descriptors. This change will require all Swedish universities to revise their program goal statements. For engineering degrees, the degree requirements are now proposed to be based on the Dublin descriptors, complemented with some specific requirements, applicable only to the engineering domain [8]. However, the Dublin descriptor-based degree requirements are abstract and do not include any goals specific to a particular domain, such as mechanical engineering. They are therefore not specific enough to guide a particular program development process. It will still be necessary for each program to work out its own program goals. After having examined that a CDIO syllabus-based program goal statement would fulfil all of the new national degree requirements, as well as offer a better support for program development, Chalmers decided to base its program goal statements on the CDIO syllabus.

Some of the programs have adopted a CDIO-based curriculum including design-build-test experiences etc. Other programs, notably master programs, have an emphasis on science, and prepare for doctoral studies and a research career, rather than an engineering one. Thus, Chalmers' goal for the introduction of IPD's is not that all programs should be CDIO-based in the sense of adapting Standard One [14] and having a CDIO-based curriculum. The goal is rather to use the CDIO toolbox in order to make sure that all programs have clear, comprehensive, and by the program's stakeholders validated program goals, along with a curriculum that meets these goals, and where there for each course in the program is a clear link between the program goals and the course learning outcomes.

As compared to the KTH single-program implementation, a number of modifications were made in order to support to the multitude of programs and diversity of programs affected:

- a higher emphasis was placed on the statement of goals for disciplinary knowledge, with the aim to raise the precision, clarity and specificity of these goals, and to support a discussion of the scope of different programs
- the importance of an explicit and thought-through statement of a program idea has been emphasized, one reason being that many of the master programs are new, while having a basis in existing courses. The change caused by the Bologna process is an opportunity for program renewal, but that also requires that time and mental energy are spent on discussing the high-level, conceptual design of the program rather than on combining existing courses into a new program
- a simpler X/0 notation is allowed in the program design matrix, the more refined ITU categorization of the mapping between goals and courses used at KTH is optional
- the validation of the program goals and the determination of desired proficiency levels on are determined through dialogues with key stakeholders rather than using the CDIO syllabus survey, the argument being that many of the programs are new master programs to be launched in 2007, currently without alumni or students to survey. The key fora for these dialogues are the program boards, committees with 10-12 student, faculty and industry representatives that act as "Voices of the Stakeholders" during the process.

The process of creating the new IPDs is led by the program chairs, in close collaboration with program coordinators and the program boards. The process is supported by pedagogical experts, who offer counselling and feedback and arrange workshops and other activities that move the process forward. The process is further supported by a set of guidelines [15] with recommendations on the appropriate level of detail, how to set goals for disciplinary knowledge, how adapt parts of the CDIO syllabus to a program's specific context, for example by modifying terminology ("build" rather than "implement") or by pruning parts of the CDIO syllabus that are not considered relevant for a program (e.g. "Operate" for a master program in Fundamental Physics, and how to connect items from the CDIO syllabus with cognitive verbs in order to state proper learning outcomes. The process of developing the IPDs is currently (May 2006) in the initial stage. Most programs have so far addressed the program purpose and goals, with program idea and program plan in draft status. It is therefore too early for any definite conclusions on the applicability of IPDs and outcomes of the process. However, some initial impressions are discussed below.

DISCUSSION

The above sections have discussed the concept and application of an integrated program description. Now, let us discuss some insights of benefits and challenges that have emerged during the course of the work.

Benefits

There are a number of ways in which the use of IPDs can contribute to the increase of the quality of the program development process.

First, they promote a goal-oriented and systematic program development process from start to end. Initially, a complete set of program goals is identified and the desired levels of proficiency established with the input from program stakeholders. Ultimately, it is made sure that these goals are allocated to individual courses, and reflected in the course goals and assessment. An integrated program description where the required contribution to the program goals from each course is explicitly stated is also known as constructive alignment [16], i.e. the purposeful relationship between program goals, intended learning outcomes, teaching and learning activities, and assessment. This is particularly important in an integrated curriculum where particular knowledge, skills and attitudes are taught in several courses, and more than one course contributes to the expected proficiency of many engineering skills and attitudes.

At KTH it was evident that faculty presented considerable more interest in contributing to the teaching of personal, interpersonal and system building skills when being aware of that almost every course in the program contributed, not only their own. Faculty at KTH also showed more understanding and appreciation for the generic skills when realising that the coordinated teaching of these skills would be beneficial for later advanced courses.

Considering the significantly amount of time spent on the development of the IPD it is of course also of interest to see if the “map” mimics the reality. At KTH this was investigated by an independent review of the integrated program description by six third year students. According to these students the program is executed according to the plans with only one minor exceptions, the most important being the “development route” for CDIO Syllabus topic 3.3 Communication in Foreign Languages.

The use of IPDs helps shift the emphasis of program development discussion towards front-end, high-level issues such as program goals and idea. Without a framework that makes such decisions explicit, it might easily happen that the most of the discussion revolves around the current program plan and how to make minor changes to it. Such an approach may be adequate under some circumstances, but it can also be very conserving in situations were major changes are possible or even necessary.

The IPD framework also provides a process template for program development. Many program chairs lack training and experience in design methodology, but are nevertheless faced with a very complex design task, involving many requirements, issues, solution alternatives, trade-offs and people. The IPD process may then help them plan and carry out this task in a time-efficient fashion without making a quick jump to making minor adjustments to the existing program plan.

The use of IPDs also brings along a common terminology for program development at a university, and collects all information that needs be produced during the process. This facilitates sharing information and comparisons between programs and faculty, and increases the transparency of the program development process. The involved faculty can follow and contribute to the process. In addition, the practical work with the tools help faculty self-reflect on their teaching practices and may lead to new ideas on how their courses can contribute to the development of generic competences in the program.

Finally, it should be pointed out that these benefits are not dependent on that the program is CDIO-based. As is evident from the application of IPDs at Chalmers, the benefits due to an increased systematization, involvement and communication in the program development process extend also to science-oriented programs.

Challenges

There are also a number of challenges associated with the development of the integrated program description.

The first, and perhaps most important, is the difficulties for faculty to see above the topical content of a course plan and to raise their perspective towards formulating the appropriate learning outcomes. This is related to the difficulty for many faculties to consider the content of their respective courses in terms of what is beneficial for the program and the students, and not for the disciplinary content itself. The learning outcomes also need to be combined with teaching activities in order to explore the constructive alignment of the integrated program description. The readability of the program description is considerably increased if faculty can recognise the real teaching activities that they many times know although they do not know the learning outcomes.

The second challenge is to determine the appropriate level of the detail of the CDIO Syllabus knowledge and skills. In an integrated curriculum this is an unavoidable challenge that is best handled by very carefully choosing the level that is appropriate for the particular program. A too high level of detail may result in a very large program design matrix that may be difficult to overview and understand for someone who has not been involved in the development of the matrix, especially if the ITU classification is used. The Swedish version of the CDIO Syllabus contains 16 topics on the second level. These are typically taught in several courses, and one course seldom completely covers the second and third levels of the syllabus. However, the third level has more than 65 topics, and most of these topics are only covered in a few courses. Figure 4 indicates the level of detail chosen at KTH, where the program design matrix contains items from both the X.X and the X.X.X levels in the CDIO Syllabus.

A third challenge is to translate the CDIO Syllabus to a terminology appropriate for the engineering discipline covered by the program. Although the language of the Syllabus is chosen to reflect as many different engineering disciplines as possible, faculty and other stakeholders will have difficulties using and accepting the Syllabus and the integrated program description if they consider the terminology inappropriate.

A fourth challenge is related to the realism in the program idea. Too radical ideas may not be possible to implement, e.g. if faculty lacks the appropriate competence and knowledge or just do not like the ideas.

Finally, as the disciplinary knowledge content in an engineering program is much larger than the CDIO content, there is always a risk that the CDIO aspects drown in the discussion of the disciplinary knowledge details. The intent of IPDs is to provide a flexible platform for the concurrent consideration of non-technical skills and disciplinary knowledge which is applicable also for non-CDIO-programs. However, the program chair needs to make a concentrated effort to make sure that all goals are discussed at adequate length during the program development process. One way to avoid this problem is to leave out the detailed disciplinary course content from the program design matrices and rely on that this knowledge is discussed in other ways.

CONCLUSIONS

Integrated program descriptions which include the purpose, goals, idea, program plan, design matrix and course plans collect the information relevant for program design process in a coherent framework.

The use of integrated program descriptions promotes a goal-oriented and systematic program development process from start to end, ensuring that the developed program has clear and validated goals and a curriculum that matches these goals. The use further supports communication between actors in the process, increasing transparency and commitment. It is not unlikely that this communication is more important for the program development than the final printed document. The concept has been applied at KTH and Chalmers for a wide variety of engineering degree programs, and is thus adaptable with respect to differences in subject area for the program, degree awarded and underlying pedagogical philosophy.

Challenges include determining the appropriate level of detail for program goals, the (optional) adaptation of CDIO terminology to that used in a particular subject area, and the balancing of efforts spent on discussing goals and content for disciplinary knowledge vs. goals and content for generic competences.

ACKNOWLEDGEMENTS

This work was financially supported by the Knut & Alice Wallenberg foundation. This support is gratefully acknowledged.

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