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A NEW GUIDELINE TO DEVELOP A LECTURE – USING THE VDI 2221 FRAME – APPLIED ON A MECHATRONIC COURSE

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Abstract

When developing lectures it is important to consider didactic methods and simultaneously work efficiently. A guideline that supports the development of lectures is missing, and the need for such a guideline is even more evident when distributed teams are developing a lecture together. This work describes such a new guideline.

The new guideline is developed by combining didactic methods and an existing guideline for product development, VDI 2221. The resulting guideline supports the development of the lecture from the idea to the final documents. The clear structure of the developed guideline ensures the processing of all important tasks, the scheduling of the different efforts and the documentation of the course.

The usage of the new guideline is validated by using it for the development of a course by a team of distributed lecturers. The lecturers found the guideline very helpful when developing the lecture and it will also be useful when developing the lecture further. Even if the structure of the guideline is strictly defined it is easy to customise.

Keywords: Didactics, Guideline, Mechatronic Course.

1 Introduction

A distributed team (Switzerland/Sweden) consisting of three university lecturer had the idea and opportunity to develop a lecture [1]. Since the lecturers where located at different geographical locations, it was not possible to meet frequently. The importance of structuring the development of the lecture to be able to work efficiently was obvious. Even though a lot of didactic expertise like [2] and [3] exists, a guideline to develop a lecture from the idea to the final documents was not found.

The aim of this work is to develop such a guideline as they are known in product development together with experienced didactic teachers in order to support the lecturer team. The resulting guideline is used when developing the new course for mechanical engineering students.

By using the VDI 2221 guideline for product development as a base and adding methods from didactics, a frame for the development work is established. The VDI guideline and the didactic methods used are described in detail in the following section.

2 Methods

A positive impact on the learning process of the students can be achieved when informing the students in advance about the educational objectives in the course [6], [7]:

- The students achieve better results.
- The questions in exams are formulated more comprehensive.
- The students profit of educational-psychological principles.

Especially when teachers mainly deal with the content of their subject, the formulation of learning objectives helps to clarify the content of the lecture and how to achieve the learning goals.

A comprehensive source for the theory of goal setting can be found in [8]. The teaching target level model of Eigenmann and Strittmatter [4] is used in this work to formulate the teaching targets on three different levels: guiding principles, disposition goals and operationalized educational objectives. A similar level model can be found in [9], where also three different types are listed: teaching targets with high, medium and low abstraction.

The *guiding principle* answers the question: “Why this lecture?” on a high level of abstraction and has two functions:

- It defines the scope of the subject of the lecture and helps to eliminate unimportant issues.
- It arranges motivations for the lecture in a criticizable manner and thus allows rational argumentation on education planning.

Disposition goals focus on the behaviour, the attitudes and motivations of the students. They answer on a medium level of abstraction the questions:

- Which behaviour, which attitudes are required for the lecture?
- Which behavioural forms or personal characteristics will be changed throughout lecture in which way?

The *operationalized educational objectives* describe the observable, measurable and testable behaviour after attending the lecture on a low level of abstraction. They consist of four elements:

- The observable final behaviour of the students
- The unambiguous description of the object related to the educational objective
- The description of the necessary conditions or allowed means
- The specification of the benchmark for the sufficient behaviour

A design methodology in general does not only consist of (didactic) methods but also of a structured procedure and tools [10]. The corresponding tools such as text software are described explicitly in the method or are obvious. There is a lack concerning the structured procedure when producing a new course. While developing a new course it is not obvious where to start and what to do when. Aspects from the concurrent engineering are needed if several persons are involved in the design of the course. When investigating the structured procedure to be followed during the course development, it turned out that the framework in the established design guideline VDI 2221 [5] depicted in Figure 1 is a very useful entry point to embed all necessary design steps. All stages are ordered, described and the corresponding target results for each stage are specified.

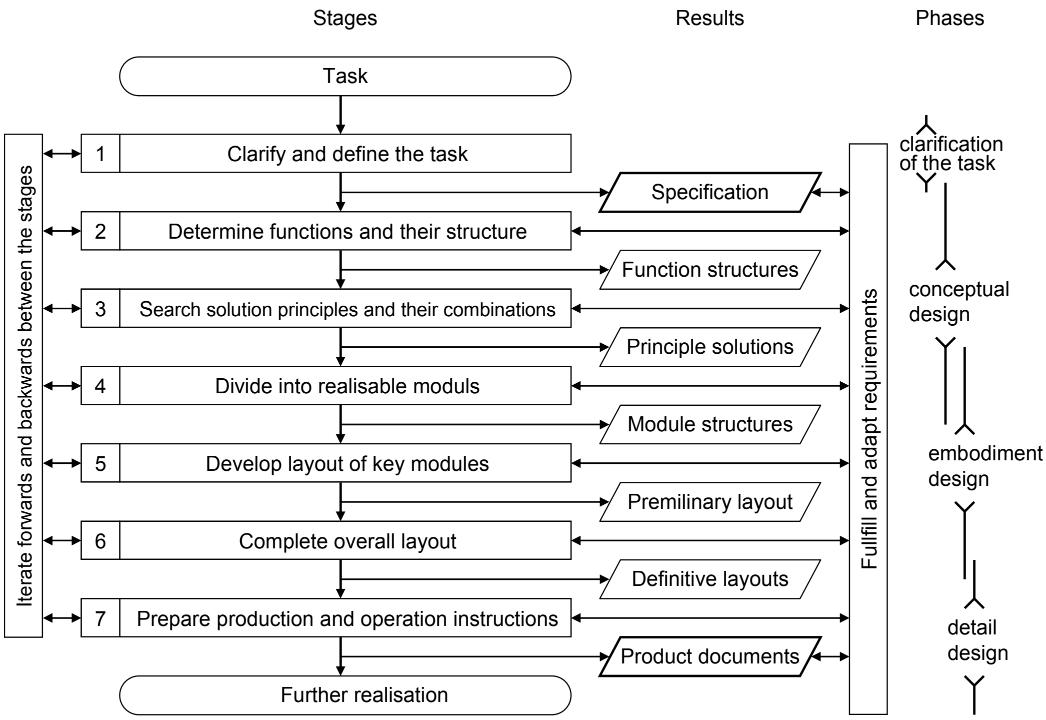

Figure 1. Structured procedure in the product development guideline VDI 2221

3 Guideline

The intention of the presented work is to provide a pragmatic guideline which structures the process of content creation and integrates the major didactic concepts. One course [1] has been fully developed according to the new guideline. The clear structure of the presented guideline makes it easy to adapt the guideline according to the own needs.

Analogue to the design guideline VDI2221 [5] stages, results and four phases are introduced. The task is to develop a lecture, in this case the lecture “Methods and Tools for Developing Mechatronic Products” as shown in Figure 2.

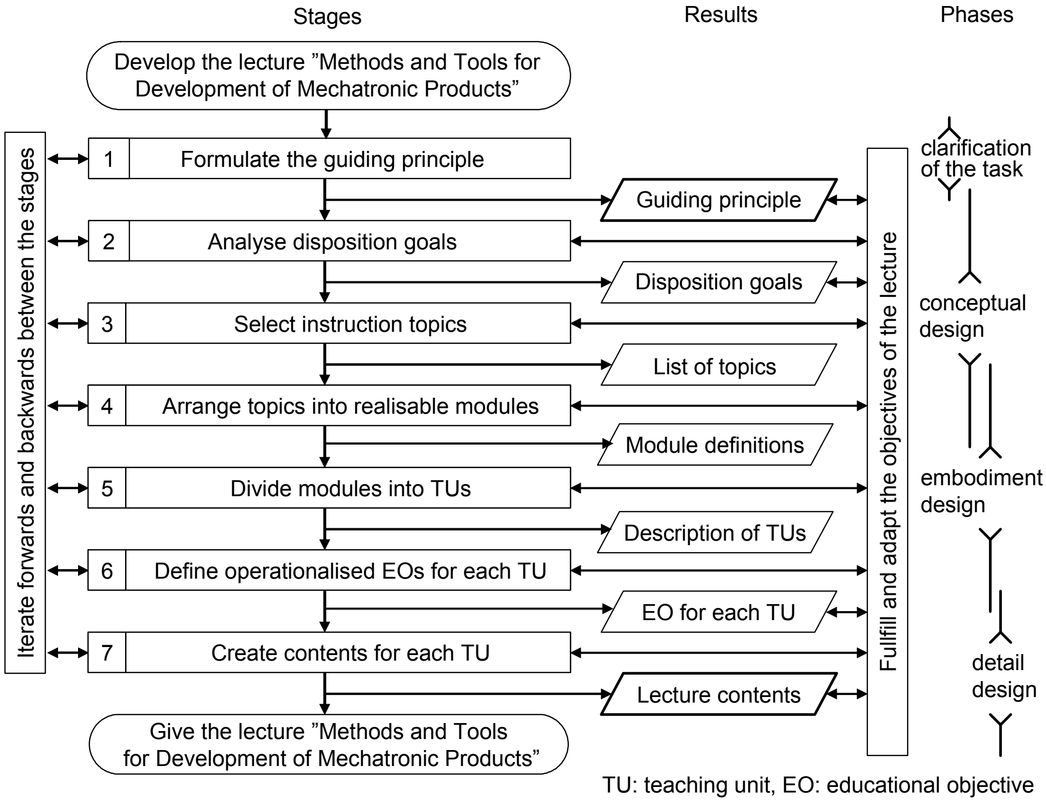

Figure 2. Guideline to develop a lecture

Seven stages are leading to the final course material. Each stage is described and exemplified in the following sections. Iterating forwards and backwards between the stages (left box) is considered as in [5]. Instead of continuously adapting the product requirements as it is proposed in [5], the objectives of the lecture are revised permanently. A major change of the objectives will affect directly the first two results 'guiding principle' and 'disposition goals', which obviously have an impact on all following stages. A small specific change of the course objective will directly affect the educational objectives from stage 6 and influence stage 7. To clarify the task 'develop a lecture' it is important to formulate the guiding principle.

3.1 Formulate the guiding principle

The guiding principle motivates the lecture on a high level of abstraction as described in chapter 2 and in [4], [9]: Why this lecture, this topic? Why is it relevant? Why should it be taught? It defines the purpose of the lecture.

The basic form of the guiding principle consists of two parts: It starts with a situation, a claim, a general conclusion or a norm and is followed by possible consequences for educational tasks.

Example from the mechatronic course developed by the authors:

"The number of mechatronic products/modules is constantly increasing. Traditional design methods do not cover the interdisciplinary design aspect. In this lecture the mechanical engineering students shall learn methods and tools to develop mechatronic systems from a holistic point of view."

3.2 Analyse disposition goals

Disposition goals are describing the behaviour of the student in future subject-related tasks and problems after having attended the class (chapter 2 and [4], [9]). More precisely, disposition goals deal with the following matters:

- How does the lecture achieve a change in the behaviour of the students?
- What kind of new behaviour is desired by the education?
- What are the new structured procedures caused by the lecture?
- In what kind of situations will the student benefit from the lecture?

Example from the mechatronic course:

Four disposition goals are derived to describe the desired behaviour of the students after having attended the class. One of the four disposition goals is:

“When the student is employed as a mechanical engineer in the industry he will involve the control engineer already during the concept phase. He will be able to communicate and to work on the interdisciplinary concept together with the control engineer.”

3.3 Select instruction topics

Based on the disposition goals the instruction topics can be chosen. According to [11] various criteria have to be considered. One example to select and evaluate instruction topics in physics is the “Bad Hersfelder” recommendation where sixteen aspects are listed [12]. For this guideline the following two approaches to find an adequate set of instruction topics are suggested. Both approaches can be combined.

Bottom-up-Approach:

Using the superior topic of the course to be developed as a starting point, all possible related information has to be collected and structured till a reasonable amount of sub-topics is available. Each sub-topic has to be represented by a meaningful title and enough information to make them comparable with each other. In the next step, all the sub-topics have to be tested with the leading principle and the disposition goals: Does the sub-topic support the leading principle? Will it contribute its part to an achievement of the disposition goals? Sub-topics which don’t fit with the leading principle or the disposition goals won’t be considered anymore. All the remaining sub-topics become part of the list of instruction topics.

Top-Down-Approach:

Deriving from the leading principle and the disposition goals, fictive learning contents are formulated. The question is: To achieve the disposition goals and thus to support the leading principle, which contents should be taught? The fictive learning contents have to be structured and worked out till a reasonable list of fictive topics, each represented by a meaningful title and a brief description. Each fictive topic has to be confronted with the corresponding “real topic”: Does the fictive topic in the described way exist in reality? Is there enough content available? Is it meaningful? Fictive topics which pass this test become part of the list of instruction topics.

Example from the mechatronic course:

List of instruction topics:

- Basics in mechatronics
    - Actuators and Sensors
    - Classification of controls
    - Tools
    - ..
- Programming controls
    - PLC
    - NC
    - ..
- Interdisciplinary design process
    - VDI 2206
    - ..
- Machine Simulation
    - Event simulation
    - Dynamics, kinematics
- Virtual initial operation
    - VR
    - Connecting the tools
    - ..

3.4 Arrange topics into realisable modules

The instruction topics can be structured by arranging the topics into realisable modules. The estimated time consumption for the student has to be determined for each module. This helps to meet the target time consumption for the whole course.

Analogue to product development, modularisation does not only structure the product but does also enable concurrent engineering. Responsibilities can therefore be defined per module, if more than one lecturer develops the course.

Example from the mechatronic course:

Since the three lecturers Stefan Dierssen, Anders Jönsson and Jens Bathelt where developing the mechatronic course concurrently on distance, the modularisation and fragmentation of the responsibilities became very useful:

Table 1. Modules

Module number	Module name	Hours	Responsible
1			
2			
3	Programming a PLC	6	Jens Bathelt
…			

In this case the time frame was 3 hours per week, where one hour implies 45 minutes contact with the students.

3.5 Divide modules into teaching units

A teaching unit is a self contained fraction of a module which uses one certain instruction method and lasts between thirty minutes and ten hours [2]. An instruction method can be a presentation by the teacher, laboratory, case study, a project, programmed learning, etc. [13]. To enrich the lecture, diversity of methods should be emphasised. The separation into teaching units has to be done in a manner which supports the leading principle and the disposition goals.

Example from the mechatronic course:

The idea of this course was to have one hour theory in a lesson and two hours exercise working on a case consolidating the theory. Thus a teaching module consists in this case of one, two or three lessons and corresponding cases. Table 2 lists all lessons and cases scheduled for module three.

Table 2. Teaching units for the third module

Number	Instruction method	Teaching unit name	Hours	Responsible
…				
3.1	Lesson	PLC’s and SFC	1	Jens Bathelt
3.1	Case	SFC by SIMATIC S7-Graph	2	Jens Bathelt
3.2	Lesson	IEC-1131 and STD’s	1	Jens Bathelt
3.2	Case	STD by S7-HiGraph	2	Jens Bathelt
…				

3.6 Define operationalised educational objectives for each teaching unit

The operationalised educational objective consists of the four elements described in chapter 2. The formulation of three operationalised educational objectives for each learning unit is proposed in this guideline.

Example from the mechatronic course:

An example of the operationalised educational objectives for the first lesson and the first case in module three is presented in this work:

Lesson 3.1: PLC’s and SFC

- After the lesson the student is able to explain the PLC principles and properties
- The students can list and exemplify the basic programming elements from SFC
- The student is able to sketch a structured programming procedure

Case 3.1: SFC by SIMATIC S7-Graph

- After this exercise the student will be able to use the basic functions of the SIMATIC Manager from SIEMENS
- The students will be able to develop simple SFC projects with SIMATIC S7-GRAPH
- The student is able to simulate a PLC by a Soft-PLC and to run his project with S7-PLCSIM

3.7 Create contents for each teaching unit

Finally the lecture content is achieved by applying the chosen instruction methods to the particular matter for each teaching unit. About 20 instruction methods with theory and application know-how can be found in [2].

Example from the mechatronic course:

The instruction methods for the developed course are mainly lessons and cases as described in section 3.5. All lessons and cases have the following structure:

Lessons

1. Module and lesson number:
   For instance “3.1”
2. Title:
   “Programming a Programmable Logic Controller (PLC)“
3. Objectives:
   The objectives are derived form the operationalised educational objectives and shown on the first slide. The students shall be aware of the expectations from the lecturer. This list is the base to derive the questions for the oral examination.
4. PowerPoint slides with the lesson content
5. Objectives:
   The same slide is presented again and discussed with students in order to ensure the learning targets are reached.

Cases

1. Module and case number:
   For instance “3.1”
2. Title:
   “SFC with SIMATIC S7-Graph“
3. Introduction containing background information such as tools and methods used and industrial relevance.
4. Problem definition:

product
innov@tion

Module 3 Case 3.1

1 Problem definition

1.1 Learning goals

- After this exercise you will be able to use the basic functions of the SIMATIC Manager.
- You will be able to develop common SFC projects with SIMATIC S7-GRAPH.
- You will be able to run a simulation of your project with S7-PLCSIM.

1.2 Organization and procedure

You have 90 min to solve the case. Proceed according to the following pattern:

0. Read the entire set of task .... 5'
1. Solve the task "Drawing a flowchart" .... 10'
2. Solve the task "Path-step diagram" .... 10'
3. Solve the task "SIMATIC Manager" .... 10'
4. Solve the task "Creating a SFC with S7-GRAPH" .... 40'
5. Solve the task "Simulating with S7-PLCSIM" .... 15'

The problem definition contains the learning goals which are derived from the operationalised educational objectives. As in the lesson, the student shall know what he should be able to do after the case. The second part of the problem definition provides a time frame and a list of all tasks.

5. Task description:
   All information to solve each task is given in the task description.
6. Benchmark:
   It is important to tell the student how a successful case is measured. In this case an easy criterion can be given:
   " The exercise is fulfilled if the created SFC is error free and can be simulated in PLCSIM."

4 Conclusion

The guideline presented in this work is a combination of didactic methods and the VDI-2221 guideline [5] for product development. By using the frame from VDI-2221 it is possible to provide a clear structure of the lecture development process, including the different stages and results during the various process phases. The new guideline enables a concurrent approach due to the modularisation of the instruction topics. The clear definition of the results that are produced during the development process enables an easier communication of the objectives to the student and forces the documentation of the lecture. This is of course useful for both the students and the lecturers when preparing the examination. The drawback of the methodology is the overhead for following the guideline and producing the needed documents in every stage. The guideline is tested in a case study when developing a lecture with three involved lecturers. The experience gained during the case study shows that the advantages of using the methodology is much greater than the overhead disadvantages. Although the guideline is well structured, the frame is open for future adaptation to other courses and lectures.

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