Strategic Patterns for (Re)Designing Modular Curricula

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Abstract: This paper addresses the demand for reusable solutions addressing reoccurring challenges of curriculum (re)design in the higher education sector. The presented patterns respond to the tasks of considering generic competences in curricula, specifying learning outcomes throughout curricula, including curriculum stakeholder in curriculum issues, comparing taught curriculum content with content that is recommended by international experts of the discipline, and the mutual and transparent documentation of the curriculum implementation in a central curriculum wiki. The patterns were implemented in a real-life setting and the experiences gained were documented in terms of case stories. The patterns and the case stories were evaluated by experts for patterns and curriculum design. Results showed that the presented patterns were perceived as highly important for curriculum (re)design activities in order to develop higher education curricula that respond to curriculum requirements of the higher education sector.

Introduction

The European higher education sector, for example, has faced massive changes initiated and guided by the Bologna process (Bologna Declaration 2000, Prague Communiqué 2001, Follow-up Group of the Bologna Process 2005). The main goal of these changes is the harmonization of the different national higher education systems. Central challenges are, for example, the implementation of the tree cycle system including bachelor-, master-, and doctorate degree levels, the generation of transparency by introducing tools like ECTS (European Credit Transfer and Accumulation) credit points and learning outcomes at different levels (e.g. learning outcomes in the European Qualification Framework and the National Qualification Frameworks, study program outcomes stated in the qualification profile of curricula, module learning outcomes and course learning outcomes); the consideration of generic (or employability-relevant) competences in higher education study programs as well as the inclusion of curriculum stakeholders in current developments in order to mutually address international requirements for higher education institutions.

The requirements for universities were communicated at a very general level. Concrete, structured, and reusable patterns describing the reoccurring problems and possible solutions how to meet or address these requirements at institutional level were missing. The motivation of our work was to fill the gap of missing concrete procedures for higher education institutions providing support to answer the question how to meet the international roughly described recommendations for higher education.

This contribution represents an overview of the work of (Kabicher 2010). Five strategic patterns that refer to particular challenges of higher education institutions were elaborated using design based research. Experiences collected during the implementation of the patterns in a real-world setting were documented in terms of cases stories. The presented patterns and the case stories in this work illustrate short versions or summaries of the patterns and cases stories described in (Kabicher 2010, pp. 204-299). The patterns and case stories were evaluated by experts for patterns and curriculum design.

The paper is structured in the following way: the next section gives an overview of the conducted study. In the third section the patterns and their implementation at the Faculty of Computer Science at the University of Vienna are presented. In the fourth section, results of the expert evaluation are discussed and in the final section we conclude our work.

The Study

Our main research question of this work was: *Are there curriculum design patterns within curriculum transformation processes that can be identified, modeled and described and which are important for curriculum* *design, redesign and implementation activities in order to develop higher education curricula that respond to curriculum requirements of the higher education sector?*

The overarching research methodology to answer the research question was design-based research, which combines theory-driven design, practice and empirical research (Design Based Research Collective 2003). Our research approach included five steps:

1. *Context description and literature review*
   The purpose of the first step was to elaborate a contextual understanding of curriculum (re)design requirements and challenges at institutional level. A comprehensive literature summary and discussion of topics particularly relevant for curriculum design and implementation at international, national and institutional level was elaborated. Focus was put on European developments and changes in higher education in general (Bologna Process), and curriculum issues that were addressed by the developments and changes in particular, e.g. learning outcomes, employability and competences, inclusion of curriculum stakeholders, quality aspects, gender mainstreaming, and new media in education.
2. *Identification of curriculum design principles*
   Curriculum design principles were derived from results of the context description and literature review. Some design principles addressed by the patterns were, for example, (a) consider competences relevant for employability of graduates, (b) find an appropriate balance of generic and subject-specific competences, (c) design and implement the curriculum as an entity, and (d) offer transparency of curriculum implementation.
3. *Description of curriculum design activities in terms of reusable patterns*
   Patterns were elaborated that address reoccurring challenges of modularized curricula of the Bologna reform era and that illustrate reusable solutions for curriculum designers at higher education institutions.
4. *Case stories*
   The patterns were implemented at the Faculty of Computer Science at the University of Vienna. Experiences were documented in terms of case stories.
5. *Expert evaluation*
   The patterns and their case stories were evaluated by selected curriculum design and pattern experts.

In the next section, the five patterns and the case stories were presented and illustrated in more detail. The patterns represent short versions of the templates used in (Kabicher 2010, pp. 204-246).

Strategic Curriculum (Re)Design Patterns

In this section we present the following five patterns and their implementation in a real-life context:

- *Consideration of generic competences in the curriculum*
- *Comparison of curriculum content with recommendations of international experts of the discipline*
- *Offer of support in specifying learning outcomes in courses*
- *Inclusion of curriculum stakeholders in curriculum design, redesign and implementation*
- *Complementation of the formal curriculum document by a web application*

The five patterns are illustrated and explained in the Figures 1-5. In the following we document our experiences of the implementation of the patterns at the Faculty of Computer Science at the University of Vienna. Beforehand, we briefly describe the context, in particular the situation at the faculty before the patterns were implemented.

Context in which the Patterns were used

The computer science bachelor curriculum was developed in 2006 and corresponded to the main recommendations of the Bologna process: the curriculum reflected a broadness of themes offering the possibility to focus particular specializations in master degree programs; it was designed in a modularized way, and included ECTS credit points.

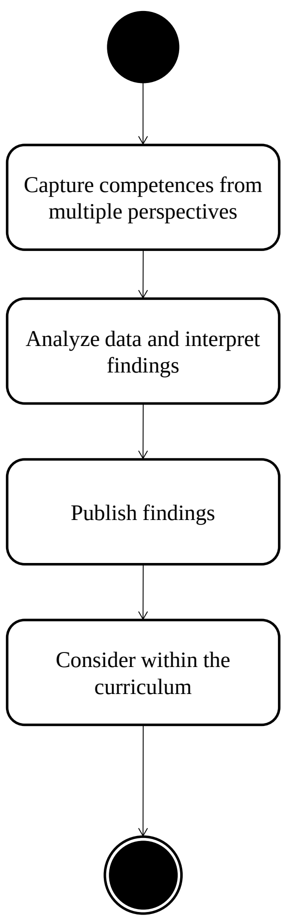
Up to the Bologna-conform curriculum, curricula offered by the faculty contained a number of courses which could be freely chosen by the students by considering a roughly framework of structure determined in the formal curriculum document. In such an environment, students were assumed to develop particular generic competences (like organizational skills, time management, fast orientation, information management, and self-directed learning) to “survive” at university. The facilitation of generic competences and the use of e.g. interactive or blended teaching- and learning methods depended on the personal interest of the instructors.

Support was provided by a central center of teaching and learning at the university. Generic competences were usually not explicitly facilitated in most of the courses, unless the courses were explicitly created and offered to develop particular generic competences. The facilitation of generic competences in the subject-specific courses of the curriculum was not transparent.

The content and the learning outcomes of the modules in the formal curriculum document were described very roughly. Course descriptions reflected the roughly descriptions of the modules and thus, did not impart detailed insight into the subject-specific content taught in the courses. Available course descriptions of subject-specific courses hardly ever considered generic competences. Instructors of the curriculum often were not aware of the subject-specific content of other courses of the curriculum.

The coordination among instructors of the courses in the curriculum took place in one meeting before the semester started. Content-related coordination of courses took place in an informal way, increasingly when instructors knew each other. Detailed information about courses (e.g. detailed content descriptions, or illustrations of teaching and learning methods used in the course) was hard to find, as the information was, if at all, spread at various websites and learning platforms. Often the detailed information to a course was rather accessible to students than to other instructors of the curriculum.

Inclusion of Curriculum Stakeholders in the Curriculum



Pattern: Inclusion of curriculum stakeholders

Problem

Society demands from universities to equip students with knowledge and competences important for their future professional life and their national and international employability. A curriculum is part of a system that needs to be considered as a unique and holistic one even if there are many situations that seem to be similar at the surface. Each curriculum has impact on the system, e.g. on the society, economy and the individual. In return, the environment influences the curriculum. To provide a curriculum and the educate graduates with the intended impact on the system it seems to be necessary to consider the perspectives of various high influence curriculum stakeholders in curriculum (re)design and implementation.

Context

The inclusion of curriculum stakeholders demands for a higher education institution that:

- Is aware of the importance of generic competences for graduates' employability.
- Is committed to integrate generic competences in the curriculum.
- Is open to include stakeholders' perspectives in curriculum issues.
- Considers employability in a lifelong learning perspective rather than as a reaction on short term requirements of the labor market.

Solution

This pattern helps to consider expectations and requirements of curriculum stakeholders concerning competences of graduates in curriculum design, redesign and implementation. The goal of the stakeholders' inclusion is to consider, in addition to the main focus on subject-specific education, the generic competences relevant for graduates' employability and to develop curricula with a value for society, economy and the individual.

- Capture competences from multiple perspectives: survey employers, graduates, students and teaching staff and analyze job offers that refer to graduates of the discipline under investigation in order to get an idea of what stakeholders of a curriculum require or expect from graduates of a particular discipline.
- Analyze data and interpret findings: Compare findings among each other and with other studies in general (e.g. "Tuning educational structures in Europe").
- Provide access to findings for faculty members, the scientific community and persons responsible for curriculum design issues.
- Consider within the curriculum: Capture subject-specific and generic learning outcomes in the graduates' qualification profile of the curriculum, find ways to develop generic competences throughout the curriculum, and discuss with teaching staff ways of facilitating generic competences during the courses.

Figure 1: Pattern - Inclusion of curriculum stakeholders in the curriculum (Kabicher 2010, pp. 205-215)

The main goal of implementing the pattern "inclusion of curriculum stakeholders in the curriculum" as described in Figure 1 at the Faculty of Computer Science was to discover the stakeholders' perceptions of what competences were important for computer science graduates and to discuss and consider the identified perspectives within the instructors team of the curriculum.

Actions that were taken included a multifaceted empirical study (mainly following the international project “Tuning educational structures in Europe” (Tuning Project 2004)) including questionnaires on competences for employers who demanded computer science graduates (35 participants of the study), faculty’s teaching staff (17 participants of the study), faculty’s computer science students (126 participants of the study), and faculty’s computer science graduates (65 participants of the study), and a qualitative content analysis of job offers referring to computer science students in Vienna and surrounding (128 announcements by 58 employers). A detailed illustration and discussion of the empirical study and its results were presented in (Kabicher, & Motschnig-Pitrik 2010; Kabicher, Motschnig-Pitrik, & Figl 2009). The analysis and comparison of the results revealed that, summarized, there were several competences rated as important by all stakeholders (employers, graduates, students, and instructors. Among others, these competences were the capacities for analysis and synthesis, for applying knowledge in practice, problem solving, capacity to learn, ability to work autonomously and team competence. Overall, results were in line with finding of international, university-overarching studies (Tuning Project 2004).

Results of the study were discussed in the teaching community in a faculty-wide workshop in which the following conclusions could be elaborated: subject-specific instruction must not be neglected due to a too heavy concentration on generic competence facilitation; students needed to be sensitized for self-awareness related teaching and learning methods as soon as they enter university; individuality of participants of a learning setting had to be retained; and the explicit facilitation of generic competences required the decision and the openness of the faculty’s instructors and means that support such training.

Some lessons learned of implementing the pattern “inclusion of curriculum stakeholders in the curriculum” at the faculty were: (1) questionnaires on competences and the analysis of job offers served as “sensing tools” of institutional thinking and team learning. (2) A clear commitment for the explicit facilitation of generic competences is required by the faculty in order to support a coordinated development of such competences throughout the curriculum. (3) The purpose and the reason for developing generic competences in the curriculum need to be discussed and communicated within the faculty in order to strengthen the awareness for the importance of such competences for graduates. (4) Arising fears need to be addressed and transparently discussed in the faculty, e.g. apprehensions that there might be a shift of concentration from subject-specific towards generic competence heavy curricula.

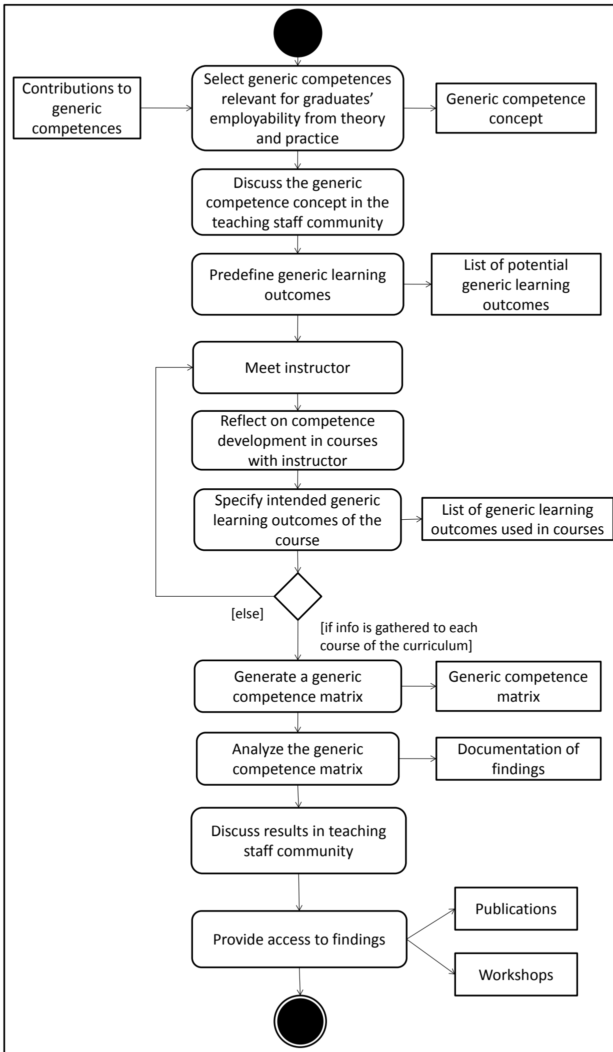
Consideration of Generic Competences in the Curriculum

The main goal of implementing the pattern “consideration of generic competences in the curriculum” as illustrated in Figure 2 was to elaborate a generic competence concept for computer science education (Kabicher, Derntl, & Motschnig-Pitrik 2008), which was based on strategic documents and contributions (e.g. Senge 2006; Tuning Project 2004; Metzger 2005), and to complement the concept with generic competences actually (implicitly or explicitly) facilitated during the implementation of the courses of the computer science bachelor curriculum which reflect the institutional capabilities.

Actions that were taken included the elaboration, presentation and discussion of the generic competence concept for computer science education in the faculty. In order to collect all the generic competences (implicitly or explicitly) facilitated throughout the courses of the curriculum in a structured and comprehensible way, instructors were interviewed in individual and personal meetings. In these personal exchanges, instructors reflected their courses and indicated generic learning outcomes that they considered as facilitated by particular teaching and learning methods used in the course. Instructors could choose predefined generic competences from a list or add generic learning outcomes if they were not jet included in the list.

As a result, the generic competence list (or matrix considering the generic learning outcomes in the rows and the courses of the curriculum in the columns) encompassed 51 intended generic learning outcomes which could be clustered into 10 categories (e.g. problem solving, multimedia competence, and scientific competence). The matrix was analyzed according to the frequency of the generic learning outcomes, e.g. their frequency throughout the curriculum including all application areas (the most frequent generic learning outcomes were, for example, the ability to analyze, to abstract, and to work and learn autonomously), the frequency in courses of particular application areas (e.g. team competences was particularly often mentioned in business informatics), the frequency of the generic learning outcomes in course types (e.g. in lectures most frequent generic learning outcomes referred to the ability to reflect and to critically question theories and methods).

Results were presented in the faculty which lead to the discussion of important questions like “Can all these generic competences that were implicitly or explicitly facilitated in the courses be assessed and thus be assured by the curriculum?”; and “Should particular generic competences be explicitly included in the qualification profile of the curriculum and if yes, which one?”. Although some of the questions remained open, the generation and the analysis of the generic competence matrix offered insight into what generic competences were stated as being facilitated by particular learning and teaching methods by the instructors. Findings could be used as basis for further discussions and considerations regarding the curriculum.



Pattern: Consideration of generic competences in the curriculum

Problem
Graduates' employability is a worldwide endeavor imposed on higher education systems. The challenge is to equip students with knowledge, skills, and competences which they will need in their professional life and future careers.

A range of recommendations for generic competences are available that reflect the "most important" ones for graduates, e.g. of a particular discipline, in a particular region. Such recommendations are necessary and important for curriculum designers as they refer to results of interdisciplinary, cross-cultural studies and reflect requirements and expectations of curriculum stakeholders across disciplines. However, the lists of recommended generic competences often differ in extent and purpose and hardly consider the institutional setting (strengths, potentials, culture, etc.). Curriculum designers face the decision if one predefined list of generic competences be interlaced in the curriculum in a top down approach, or are there generic competences particularly important in individual programs at individual faculties that should be taken into account as kinds of seeds to be nurtured according to the specific capabilities of staff, students, organizational culture, regional aspects, and situational opportunities?

Context
The consideration of generic competences in the curriculum is useful in curriculum settings in which:

- Most of the courses are not yet described in terms of generic learning outcomes additional to subject-specific learning outcomes.
- Generic learning outcomes were not analyzed across the curriculum.

Solution
The solution describes a mixed top-down and bottom-up approach of developing a list of generic competences that were partly predetermined from strategic documents and partly derived from actual teaching and learning practices as reported by teaching staff. The bottom-up approach is used to uncover generic competences that are (implicitly or explicitly) expected from students by faculty's teaching staff and which indirectly resonate throughout the implemented curriculum. The top-down approach is used to select these competences that promise to be particularly important for graduates' employability at an international level.

Figure 2: Pattern - Consideration of generic competences in the curriculum (Kabicher 2010, pp. 216-223)

Some of the lessons learned were that: (1) the generic competence list supported the instructors during the reflection of their courses as it allowed them to easily select a predefined learning outcome. (2) The bottom-up approach led to a comprehensive range of generic competences stated by the instructors. (3) The analysis of the generic competence matrix offered insights into the implicit and explicit facilitation of generic competences throughout the curriculum and raised questions that need to be discussed with curriculum decision makers.

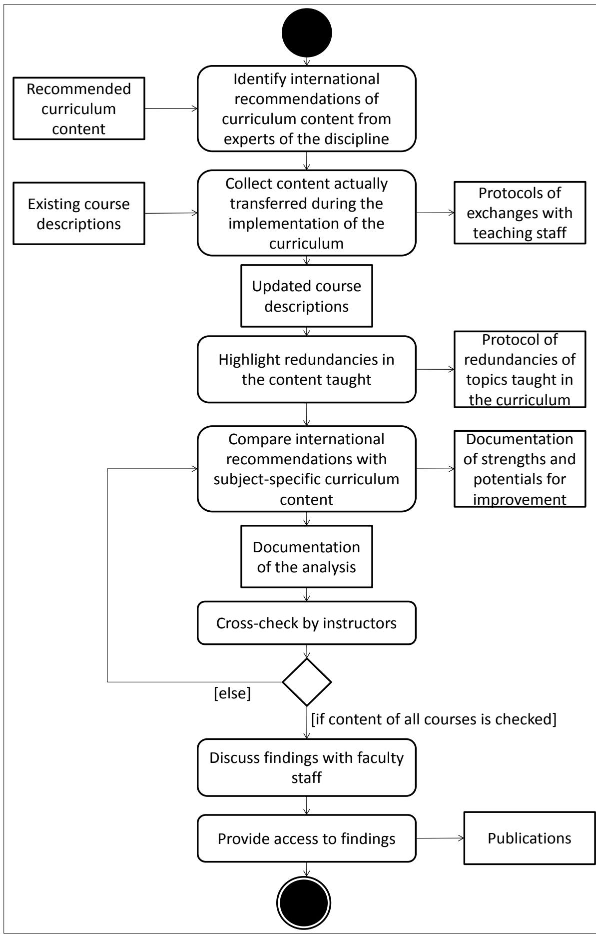
Comparison of Curriculum Content with Recommendations of International Experts of the Discipline

The main goal of implementing the pattern "comparison of curriculum content with recommendations of international experts of the discipline" as illustrated in Figure 3 was to contrast actually taught subject-specific content in the courses of the curriculum and international recommendations that refer to undergraduate computer science curricula (Interim Review Task Force 2008).

Actions that were taken included the gathering of subject-specific content taught in the courses at a very detailed level (mainly by directly consulting the instructors of the courses and partly by visiting course sites) and the preparation of the recommended content for computer science curricula in order to be able to compare data.

As the content taught in most of the courses was formulated in German language and the international recommended subject-specific content for computer science curricula was communicated in English language, the comparison of the data was a challenging task and the initial analysis was done manually. Results of the initial comparison showed that particular core topics (e.g. information management, net-centric computing or human-computer interaction) were fully covered and some core topics (e.g. algorithms and complexity, programming fundaments, and software engineering) were to some degree covered in the courses of the computer science bachelor curriculum (findings needed to be regarded with caution as the comparison of topics did not consider the amount of hours mentioned in the recommendations (Interim Review Task Force 2008)). After the initial comparison of the data results were cross-checked by selected instructors. Results of the cross-check showed that it was necessary to examine the results of the comparison by the instructors as some content lists of courses were not complete or were formulated at a higher level of granularity. Furthermore, several redundancies of content taught in the courses could be identified.

Results were discussed in the faculty and resulted in the conclusions that mechanisms might be considered that allow an automatic analysis of the percentage of topic coverage of a particular course, module and module group during the implementation of the curriculum. Discovered redundancies were pursued.



Pattern: Comparison of curriculum content with recommendations of international experts

Problem

Subject-specific learning outcomes in general and subject-specific content in particular illustrate the profile of a curriculum and are crucial for its identification and comparability. Particular subject-specific topics that are required from each graduate of the discipline from an international perspective should be considered in the curriculum content. Curriculum decision-makers should not only be aware of recommendations of the profession to which the degree program corresponds but also adapt these recommendations in order to be able to offer high quality and international competitive education. Additional to such “core topics” it is important to ensure that the subject-specific content of the curriculum reflects characteristics, the research spectrum and the competences of the particular institution.

Context

This pattern demands for curriculum settings in which:

- curriculum content is roughly described in terms of learning outcomes, learning goals or descriptions of modules.
- instructors enjoy some freedom within a particular framework to choose and concentrate on particular topics of a broader theme.

Solution

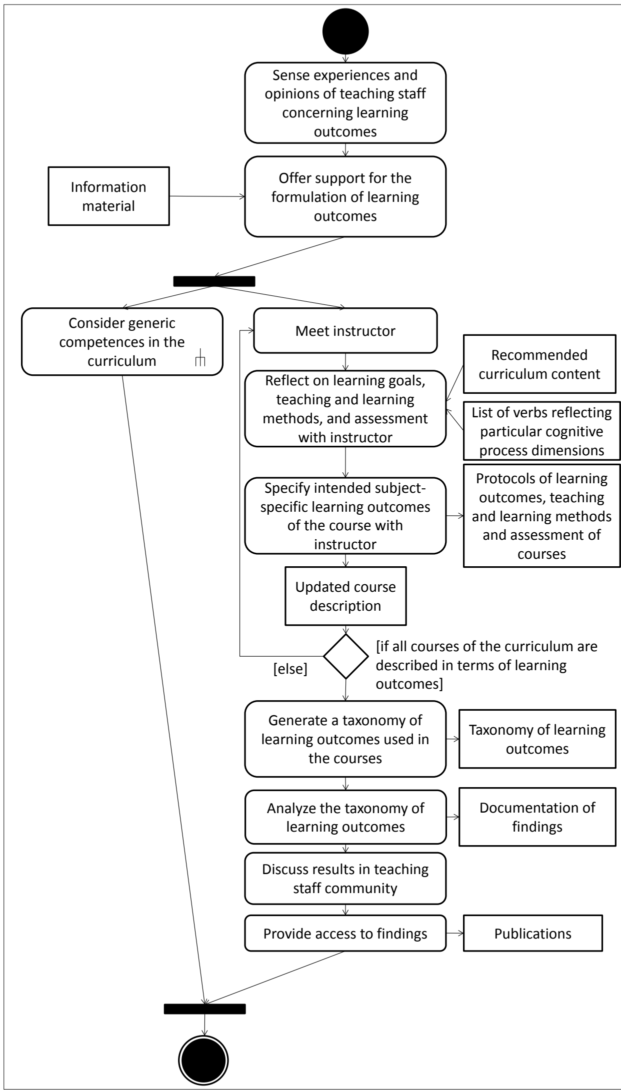
This pattern helps to identify gaps between taught curriculum content and internationally recommended topics and learning outcomes that should be achieved by each graduate of the discipline. It includes, among others, the identification of international recommendations of curriculum content from experts of the discipline, the collection of subject-specific content which is actually transferred during the implementation of the curriculum, the detection of redundancies in the content taught in different courses, the comparison of international recommendations with the identified subject-specific content transferred during the implementation of the curriculum, and the discussion of findings of the comparison with faculty staff.

Figure 3: Pattern - Comparison of curriculum content with recommendations of international experts (Kabicher 2010, pp. 224-230)

Some of the lessons learned were that (1) a detailed description of course content provided an adequate basis for identifying redundancies, (2) comparison of course contents and recommended content of international experts asked for a cross-check by instructors due to incomplete content lists or content mentioned at a higher level of granularity, and (3) the comparison of subject-specific content on a regular basis asks for automatic mechanisms.

Offer Support in Specifying Learning Outcomes in Courses

The main goal of implementing the pattern “offer support in specifying learning outcomes in courses” as illustrated in Figure 4 at the Faculty of Computer Science was to stimulate instructors to formulate student-centered learning outcomes (“Students are able to…”) at course level and at the same time to reflect their course designs regarding the alignment of the used teaching and learning methods, the assessment modes, and the learning outcomes.



Pattern: Offer support in specifying learning outcomes in courses

Problem

The use of learning outcomes in study programs becomes necessary to facilitate the comparison of knowledge, understanding, and skills. Learning outcomes are used as a tool to allow flexible learning paths in a lifelong learning perspective, and to facilitate mobility (includes both mobility within various educational systems of other countries and mobility between vocational education and training and higher education).

Context

This pattern is useful in curriculum settings in which:

- The curriculum including all its modules is (partly) described in terms of learning outcomes.
- Expectations concerning what students should achieve after a course are hardly described by instructors in terms of learning outcomes.
- The actual implemented content of the curriculum is not or just to some degree transparent to the instructors of the curriculum.
- Instructors have to take care of formulating and publishing learning goals or outcomes of a course. Furthermore, the responsibility of the adjustment of learning goals or outcomes, teaching and learning methods as well as the assessment of outcome achievement is taken by instructors.

Solution

This pattern focuses on the support of instructors to specify learning outcomes in their courses. The specification of learning outcomes takes place in face-to-face meetings in which instructors are stimulated to reflect on their courses in order to be able to formulate learning outcomes that are coherent with the design, delivery and measurement of learning. Transparency of the intended interaction of learning outcomes, teaching and learning as well as assessment methods should provide a deeper understanding of how the curriculum is actually implemented and what knowledge, skills and competences are mainly intended to be developed.

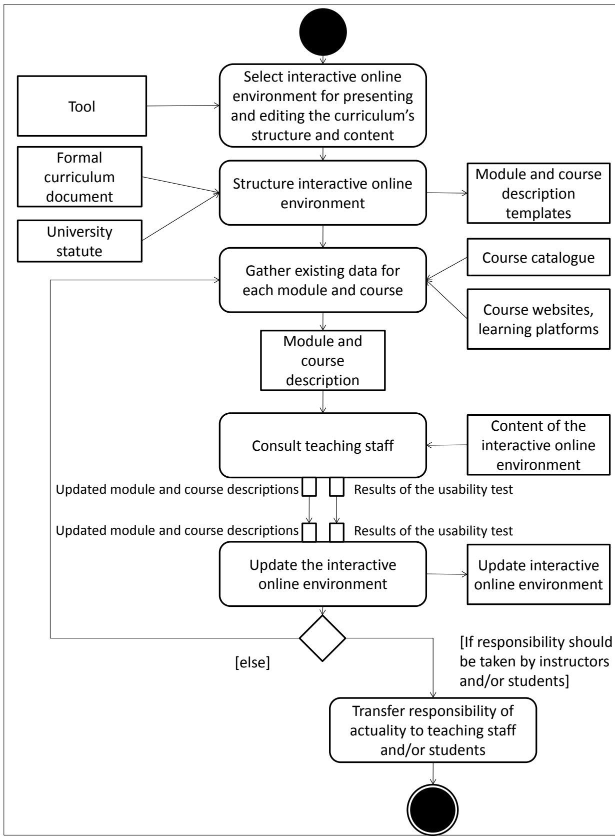
Figure 4: Pattern - Offer support in specifying learning outcomes in courses (Kabicher 2010, pp. 231-239)

Actions that were taken included the sensing of the instructors’ experiences and perspectives concerning learning outcomes in a faculty-wide workshop in which the concept and the existing demand for learning outcomes were discussed. A website was elaborated to summarize information about learning outcomes in order to provide some orientation and insight into the theme for instructors. Instructors were individually consulted to reflect on their courses particularly regarding the goals and the intended outcomes of the course, the content, teaching and learning methods and assessment mode. The information was collected in a faculty-wide interactive curriculum environment which was accessible for all instructors of the faculty (compare with pattern “complementation of the formal curriculum document by a web application”). In order to support instructors to formulate learning outcomes, a list of predefined verbs reflecting particular cognitive process dimensions (like remember, understand, apply, analyze, evaluate, and create) (Anderson, & Krathwohl 2001) was provided to the instructors. The subject-specific learning outcomes formulated by the instructors were captured in an excel file to allow their analysis.

Altogether 354 subject-specific learning outcomes were formulated by the instructors of 99 of a total of 117 courses of the computer science bachelor curriculum (including redundant learning outcomes). The learning outcomes differed in their granularity level (some learning outcomes were formulated very detailed whereas others were deliberately roughly formulated in order to leave some space for flexibility). The collected subject-specific learning outcomes throughout the computer science bachelor curriculum were analyzed according to their nouns and verbs (Anderson, & Krathwohl 2001). Results showed that most of the subject-specific learning outcomes could be categorized into the conceptual knowledge (255 learning outcomes) and procedural knowledge (226 learning outcomes) dimension and most of them referred to the cognitive process dimensions “understand” (187 learning outcomes) and “apply” (97 learning outcomes). Learning outcomes were further analyzed according to their occurrence in course types and the used teaching and learning methods (e.g. particularly in lectures and seminar courses most learning outcomes addressed the cognitive process dimension “understand” of conceptual knowledge; the learning outcomes were supported by face-to-face activities like frontal talks, discussions in groups, excursions and guest lectures, as well as by online activities like forum discussions, reflections in electronic diaries, reaction sheets, and the elaboration of online case studies).

Some lessons learned were, for example, that (1) the space to reflect on courses led to an added value for instructors and the faculty; (2) the list of predefined verbs reflecting cognitive processes supported the instructors in formulating learning outcomes; (3) instructors may enjoy the support of the faculty in formulating learning outcomes, others might interpret the support as control or inspection by the faculty; therefore the intention of the support needs to be clearly communicated to the instructors.

Complementation of the Formal Curriculum Document by a Web Application



Pattern: Complementation of the formal curriculum document by a web application

Problem
The formal curriculum is commonly communicated by a static PDF file for download. This document defines the curriculum in a legally valid way. However, the formal curriculum document has only limited value for coordination among teaching staff and the support of an easy overview and orientation of the curriculum for students and instructors. In order to enhance these aspects, and to centrally capture accurate, collected curriculum information, the formal curriculum document was complemented by a cooperative online environment.

Context
This pattern is useful in curriculum settings in which:

- instructors are willing to cooperate on the coordination of the curriculum and their modules,
- and are open to innovation and transparency in teaching processes and curriculum structures.
- a coordinator initiates and pushes the process (at least at the beginning)

Solution
This pattern focuses on the complementation of the formal curriculum document by a web application in order to illustrate curriculum implementation in a transparent way and to support coordination among teaching staff of the curriculum. The web application should allow instructors to actively describe the way in which the curriculum is implemented. The interactive online environment supports instructors to contribute, to modify content and to update information on their courses and modules. It enables collaborative provision and maintenance of information on the actual content of the curriculum.

Figure 5: Pattern - Complementation of the formal curriculum document by a web application (Kabicher 2010, pp. 240-249)

The main goal of implementing the pattern “complementation of the formal curriculum document by a web application” was to offer a central and common space for sharing knowledge and for coordinating instructors of the computer science bachelor curriculum in order to be able to communicate a well-coordinated and coherent curriculum to the students.

A faculty-wide wiki was implemented in which information about the curriculum at different levels of granularity was collected. At the highest level, general information and the general structure of the curriculum was graphically and textually presented. Clickable nodes of the curriculum graph reflected the modules of the curriculum, and different edges among the nodes illustrated either formal dependencies stated in the formal curriculum document, or content-related dependencies among modules identified and described by instructors. At the middle level, information to the modules was captured (e.g. visual graphs showing the position of the module in the curriculum, and module descriptions including links to the courses of the module). At the lowest level of granularity referring to the captured information in the wiki, detailed course descriptions were offered, including e.g. the course title, id, type, credit points, content, generic and subject-specific learning outcomes, teaching and learning methods, graphical illustration of the course design, the mode of assessment, and further resources like links to learning materials. One usability test of the curriculum wiki was conducted with instructors (28 participants) and one with faculty's students (35 participants).

Most of the computer science bachelor courses (99 of 117 courses) were described in a transparent way in the wiki. Showing descriptions of related courses in the wiki, several content-related dependencies to other courses (47 dependencies) could be identified by the instructors. Furthermore, one course could be discovered that did not fit with its position in the curriculum (Kabicher, & Motschnig-Pitrik 2009). Findings of the usability test conducted with instructors were, among others, that 43% of the instructors stated transparency as their benefit of the curriculum wiki, 39% of the instructors perceived the curriculum wiki as a resource of planning. Many students (29%) liked the graphical visualization as it supported overview of the curriculum content, and the structure (abstraction levels) of the information captured in the wiki.

Some of the lessons learned were, for example, that (1) the curriculum wiki offered the possibility to participate in "curriculum learning", (2) the detailed course descriptions supported instructors and students to learn more about what and how content was transferred to the learners, and (3) the accessible and central captured information about the curriculum implementation supported the coordination among instructors.

Expert Evaluation

The five patterns and their case stories presented in the previous section were evaluated by 12 selected experts of patterns and curriculum design. Most of the experts (10 experts) were employed at the University of Vienna, one expert came from another Austrian university and another expert descended from another European university. Half of the experts worked in the field of computer science, five experts worked at centers for teaching and learning, and one expert worked in the field of philosophy of science. Three experts were professors, three were associate professors, two experts held a doctoral degree, and four experts held master degrees. Two of the experts were once or at that time vice deans, and three of the experts had already been directors of study programs.

The experts were asked to evaluate (1) the importance of each pattern, (a) for curriculum (re)design and implementation to develop and deliver higher education curricula that respond to curriculum requirements and trends of the higher education sector, (b) for particular users, like curriculum designers, directors of study programs, instructors, and (c) for supporting specific aspects, like international comparability, graduates' employability, and student-centeredness; (2) the usefulness (d) of the patterns for their reuse in other higher education curricula, and (e) of the pattern structure referring to the template used for describing the pattern.

The analysis of the expert ratings was conducted per pattern whereby the average of the ratings was calculated. Based on a scale from 5-1 (5=extremely important, 4=very important, 3=moderately important, 2=slightly important, 1=not at all important), results were interpreted in the following way: average of $\geq$ 4.5 extremely important, $\geq$ 3.5 very important, $\geq$ 2.5 moderately important, $\geq$ 1.5 slightly important, and $<$ 1.5 as not at all important. Most of the average ratings were between 4.7 and 3.5. For example, on the average, all five patterns were rated as very important (a) for curriculum (re)design activities to develop curricula that respond to curriculum requirements of the higher education sector, and (b) for curriculum designers and directors of study programs. There were also aspects considered as less important for particular patterns, e.g. the achievement of a shift from teacher-centeredness to student-centeredness in curricula. This aspect was rated on an average with 2.3 (SD 0.89) for the pattern "comparison of curriculum content with recommendations of international experts". It might be argued that this pattern tends to identify gaps between taught curriculum content and international recommendations for study programs of a particular discipline. Such an activity is comparable with traditional procedures of shaping curricula. The documented experiences of implementing the patterns for the computer science bachelor curriculum in terms of case stories were perceived, on an average, as very useful for illustrating the use of the pattern in a real-world setting.

Conclusions

In this work we addressed the gap between international requirements for higher education communicated at a high level and the missing structured and reusable guidelines or implementation descriptions at institutional level. Five strategic patterns for (re)designing modular curricula were presented describing central challenges for higher education curricula in a structured and reusable way, addressing e.g. the consideration of generic competences in the curriculum, the inclusion of curriculum stakeholders in curriculum (re)design and implementation, the offer of support in specifying learning outcomes in courses, the comparison of curriculum content with recommendations of international experts of the discipline and the complementation of the formal curriculum document by a central wiki. The elaboration of the patterns was guided by design based research. The patterns were implemented in a real-world setting, and the gathered experiences were documented by means of case stories in a structured and comprehensible way. Thus, curriculum design knowledge and experiences could be structurally described and modeled. The patterns were evaluated by experts of patterns and curriculum design. Results showed, among others, that patterns were perceived as important for curriculum (re)design of higher education study programs and that they were considered as useful for reusing them for other higher education curricula. The case stories were perceived as useful for the illustration of the pattern implementation in real-world settings.

References

Anderson, L.W., & Krathwohl, D.R. (2001). A Taxonomy for Learning, Teaching, and Assessing – A Revision of Bloom's Taxonomy of Educational Objectives, Addison Wesley Longman Inc.

Confederation of EU Rectors' Conference & Association of European Universities (2000). The Bologna Declaration on the European Space for Higher Education: An Explanation.

Design-Based Research Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. Educational Researcher, 32, 1, (pp. 5-8).

Follow-up Group of the Bologna Process (2005). From Berlin to Bergen – General Report of the Bologna Follow-up Group to the Conference of European Ministers Responsible for Higher Education, Bergen.

Interim Review Task Force (2008). Computer Science Curriculum 2008: An Interim Review of CS 2001, IEEE/ACM.

Kabicher, S. (2010). Processes and Patterns for (Re)Designing Modular Curricula and their Application in Academic Computer Science Education, PhD Thesis, University of Vienna, Austria.

Kabicher, S., & Motschnig-Pitrik, R. (2010). The Students' Voice: What Do Computer Science Students Expect From Their University Degree. In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2010, pp. 2737-2746. Chesapeake, VA: AACE.

Kabicher, S., & Motschnig-Pitrik, R. (2009). Coordinating Curriculum Implementation Using Wiki-supported Graph Visualization. Advanced Learning Technologies (pp. 742-743), IEEE.

Kabicher, S., Motschnig-Pitrik, R., & Figl, K. (2009). What competences do employers, staff and students expect from a Computer Science graduate? *Frontiers in Education Conference* (pp.1-6), IEEE.

Kabicher, S., Derntl, M., & Motschnig-Pitrik, R. (2008). Approaching Inclusive Universal Access on the Computer Science Curriculum level. *Frontiers in Education Conference* (pp.F2H-14-F2H-19), IEEE.

Metzger, C. (2005). Lern- und Arbeitsstrategien. Oberentfelden, Schweiz: Sauerländer Verlag AG.

Prague Communiqué (2001). Towards the European Higher Education Area – Communiqué of the Meeting of European Ministers in Charge of Higher Education, Prague.

Senge, P. M. (2006). The Fifth Discipline, The Art & Practice of the Learning Organization. USA, Currency Doubleday.

Tuning Project (2004). Tuning Educational Structures in Europe – General Brochure, http://tuning.unideusto.org/tuningeu/, last visit on the 17.12.2010.