A Framework for Curriculum Management
The Use of Outcome-based Approach in Practice

Martin Komenda[1,3], Daniel Schwarz[1], Jiří Hřebíček[1,2,3], Jiří Holčík[1,2] and Ladislav Dušek[1,2]
[1]*Institute of Biostatistics and Analyses, Masaryk university, Kamenice 3, Brno, Czech Republic*
[2]*Research Centre for Toxic Compounds in the Environment, Masaryk university, Kamenice 5, Brno, Czech Republic*
[3]*Faculty of Informatics, Masaryk university, Botanická 68a, Brno, Czech Republic*

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Abstract: The need for guaranteed and high-quality education involving predefined curricula covering a corresponding scope of input knowledge and skills required in subsequent practice has been gaining momentum. Universities compile their curricula so as to ensure that they cover all steps essential for the students to obtain employment later on. In the paper a brand new and original curriculum harmonization approach within tertiary education is described by adopting an outcome-based approach and applying modern information and communication technologies. We propose a model for curriculum management and show how the model was implemented into practice in a particular field of study by using complex web-oriented platform. Its primary objective is to make all efforts expended by users more efficient, as regards to the creation, editing and control mechanisms in the form of deep content inspection.

1 INTRODUCTION

The proliferation of web technologies, in conjunction with the social demand for improved access to tertiary education, have stimulated the rapid growth of e-learning (Chiu and Wang, 2008). Individualised ease of access to information resources and time flexibility or independency are the major advantages impacting the users. Today, modern information and communication technologies (ICT) offer an interesting opportunity to revolutionize the way education is provided (Barnes and Friedman, 2003). The list, annotations and curricula of compulsory subjects, compulsory-optional courses and optional seminars are available to students and teachers – typically in the local learning management systems. However, the differing levels of detail and description style lacking any kind of standardization or parameterization hamper transparency and comprehensibility, particularly when searching for information on the entire course of studies. As a result, it is very difficult to look at the whole field, specialization or studies from a broader perspective and to enjoy the possibility of searching easily across the curriculum and finding one's way through it to see what is actually being taught and how.

For many years, academic staff (such as teachers and guarantors) has been in close touch with sophisticated online educational tools. Hundreds, if not thousands, of web-based tools have been created in the last few years, taking the technology as a tool metaphor to a new level (Oliver, 2010). These systems have facilitated institutional curriculum planning activities related to the creation of well-balanced education. For an instance, the CanMEDS initiative of The Royal College of Physicians and Surgeons of Canada has introduced the implementation of a national, needs-based, outcome-oriented, competency framework that sets out the knowledge, skills and abilities for specialist physicians in order to achieve better patient outcomes (Frank and Danoff, 2007), (Frank and Bernard Langer OC, 2003). In (Huang, 2001), the author presented an integrated outcome assessment application that was completed by a database designed to accumulate learner performance outputs and to store them as a prat of learner's profile. Data from the profiles can then serve as valuable inputs in providing personalized and customized learning content or to conduct an overall performance evaluation. Y. Mong et al. (Mong et al., 2008) have described the web-based application LOTS (Learning Outcome Tracking System), which provides overall management of the learning

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outcomes and access for both the student and the teachers. In brief, LOTS consists of six components, namely group, metric, learning outcome, incident, correlation and analysis. The generic electronic portfolio called ePortfolio (Cotterill, 2004) has introduced an approach, which is being used to support the evidencing of learning outcomes and to facilitate personal development planning. In modular courses, portfolios may provide focus on programme-level as well as module-specific learning outcomes. The whole process may help students to become better at relating what they learned to the requirements of teachers. S. Kabicher et al. have presented a sophisticated approach, the use of visual modelling within an interactive online environment (ActiveCC Web) for a collaborative design, the implementation and visualization of the curriculum structure and the content (Kabicher and Derntl, 2008), (Kabicher et al., 2009). One of the options for describing the content related to the curriculum is a special taxonomy. T. G. Willett et al. have introduced TIME (Topics for Indexing Medical Education), a hierarchical taxonomy of topics relevant to medical education. The content and the structure of the topics within TIME was developed in consultation with medical educators and librarians at several Canadian medical schools (Willett et al., 2007). Existing solutions, that were published, are focused on the curriculum only from a certain perspective, offering the agenda together with selected functionalities and making the efforts to provide them to students and teachers of the respective institution in a transparent format. However, we have not yet seen a complex instrument that would cover all elements associated with global curriculum harmonization, including a detailed parametric description down to the level of the learning units, and one that would be linked to the learning outcomes (Komenda et al., 2013).

2 OBJECTIVES

Many thoughtful attempts were made in order to develop a curriculum mapping or model, which should increase academic rigor, sharpen students' critical thinking and analytical reasoning, and expose them to a richer subject matter. Consequently, three following main research strides emerged. 1) Instructional methods cover many innovative methods in higher education: active learning, experiential learning, inquiry-based learning, discovery-based learning, problem-based learning, project-based learning, collaborative and cooperative learning, and understanding by design. 2) Evaluation and assessment provide new methods developed to promote Bloom's higher-order thinking and other competencies required in the employment market such as self-assessments, students' portfolio, open book test, case studies analysis, group projects, prototyping, and technology-based evaluation. 3) Curriculum coherence and integration focus on reforms in the curriculum structure: the integration of general education across the curriculum, the integration of the disparate elements of students' learning experiences, and shifting from curriculum objectives to attaining competencies (Pasha and Shaheen Pasha, 2012). With regard to the mentioned areas, this paper introduces an innovative curriculum planning model, which is based on the outcome-oriented paradigm. This performance-based approach at the cutting edge of the curriculum development offers a powerful and an appealing way of introducing effective reforms in education management. Here, emphasis is on the product – what sort of graduates shall be produced – rather than on the educational process itself (Harden, 1999). Our research is concentrated on the following topics.

- To propose a curriculum planning model, which would channel clear communication between the involved stakeholders (supervisors, guarantors, managers and teachers).
- To develop a robust web-oriented platform for complex curriculum management, which would provide a set of effective tools to be used for creating, transparent browsing, and reviewing the curriculum in a user-friendly environment.

A pilot curriculum reform and harmonization using the described approach has been already done within the study discipline of Mathematical Biology, which is part of the Experimental Biology curriculum at the Faculty of Science of Masaryk University in Brno, Czech Republic. The goal of this field of study is to produce professionals in the domain of data analytics in clinical, biological and environmental research. It also enables to attract a new generation of interdisciplinary experts, needed for processing and analysing data from experiments as well as for properly interpreting the obtained results, including communication and collaboration with other experts in the given fields.

What will such an approach to curriculum planning and harmonization bring for the student? It will provide clear information about what knowledge shall be acquired during the whole study period, what topics will be in the schedule, what fields will be covered repeatedly and how the subjects will be interconnected with the learning units and the learning outcomes. As for the teachers, the description of the curriculum will mean an easy way of clearly defining their lessons. In addition, they will be able to browse the curriculum data from all available courses according to the predefined search parameters. And for the school managers, the presented tools will provide a practical view on the teaching. Further, it will also provide clear and comprehensible data about who teaches what and in what context, as well as information on the deficiencies and overlaps in the curriculum. One of the key benefits is a new kind of view on the correlations between the theoretical and practical parts of the study, which will help in deciding whether the overall teaching pattern is correct or some kind of restructuring is necessary.

3 METHODS

The current literature shows that the existing curriculum models are unable to represent the needs of the today's dynamic & complex education. This is due to the fact that the current society is more open, diverse, multidimensional, fluid and more problematical (Pasha and Shaheen Pasha, 2012). It is one of the reasons why the issue of innovation has been confronted in many fields as a mere tertiary field by different academic institutions, as the analysis of the current global situation indicates. However, today a coherent solution that would cover user-friendly tools for easy curriculum description is still missing. Therefore, we have proposed a methodological model, which is built on an outcome-based paradigm. The Bergen ministerial conference of the Bologna Process in May 2005 discussed reforms to degree structures, credit transfer, quality assurance and curricular development, which are transforming the European Higher Education Area. Learning outcomes are arguably best viewed as a fundamental building block of the Bologna education reforms and bring more transparency to higher education systems. They have a reputation of being rather mundane and prosaic tools, yet it is this basic underpinning function that makes them so significant. It is important that there should be no confusion about their role, nature and significance, or the educational foundations of the Bologna process will be undermined (Keeling, 2006). The use of the mentioned concept implies a fundamental paradigm shift in curriculum design for many European institutions offering higher education (Adam, 2004).

We also present here an original instrument based on approved pedagogical methodology with the integration of ICT mashups into the curriculum management process. This web-based tool called Learning outcome browser, which is part of our web/oriented platform, covers all elements pertaining to global curriculum harmonization, including detailed metadata specification down to the level of learning units and interconnections to the learning outcomes. It opens the possibility of reforming the curriculum structure effectively, as all elements are available in the form of parametric description. The organization of the data and its linking are provided in the curriculum model, which can be implemented without any restrictions within any database technology. Figure 1 shows a simplified entity relation data (ERD) model of the fundamental attributes in the proposed solution.

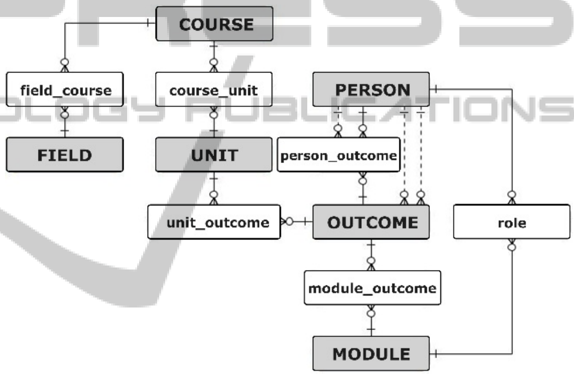

Figure 1: Simplified data model of curriculum.

There are a number of technologies used during the development process, rendering easy implementation afterwards. The web-oriented architecture runs on the most-used and widespread web servers – either an Apache server or a Microsoft Internet Information Server (IIS). We use Linux/Ubuntu and Windows Server operating systems for well-proven performance. All the tools were developed with the use of PHP (version 5.3.10), XHTML, CSS 2, JavaScript, AJAX and MySQL (version 5.5.32). We have also acquired the services of third party frameworks, such as jQuery (JavaScript library used for easier development of web-centric technologies), CKEditor (WYSIWYG text and HTML editor designed to simplify website content creation) and DHTMLX components (JavaScript grid control provides cutting-edge functionality, powerful data binding, and fast performance with large data sets).

4 RESULTS

We have proposed a model for curriculum management and harmonization and showed how the model was implemented into education in a particular field of study by using our original web-oriented platform. Its primary objective is to make all efforts expended by users more efficient, as regards to the creation, editing and control mechanisms in the form of deep content inspection. The platform enables to introduce reforms into the curriculum in several phases. Thus, unintended consequences or suboptimal solutions may be avoided.

The first phase sets up the structure of curriculum, which is described in figure 2. The study field is split into individual modules including details of the responsible supervisors. Each module contains a set of courses including its guarantors. The rules used for learning outcome definition have been already established according to the Bloom's taxonomy (Krathwohl, 2002). The composition of the study field is closely connected with the ERD model (see figure 1), which was designed to make whole curriculum domain more understandable. All the relations between modules, learning units, outcomes and involved stakeholders provide the basis for building web-based tool, which can easy organize the metadata about the education.

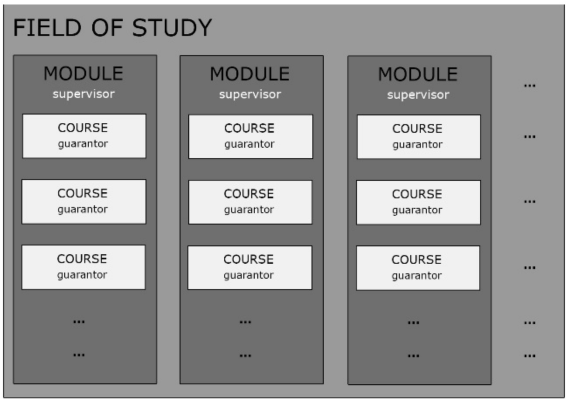

Figure 2: Proposed curriculum structure.

The second phase covers the definition of the learning outcomes (requirements on the graduate from the selected field) based on a predefined structure in an online environment including formal and semantic verification. Outcomes typically consist of a noun or noun phrase (the subject matter content) and a verb or verb phrase (the cognitive processes). Consider, for example, the following objective: The student shall be able to remember the law of supply and demand in economics. "The student shall be able to" (or "The learner will," or another similar phrase) is common to all objectives since an objective defines what students are expected to learn. Statements of objectives often omit "The student shall be able to" phrase, specifying just the unique part (e.g. "Remember the economics law of supply and demand."). In this form it is clear that the noun phrase is "law of supply and demand" and the verb is "remember" (Krathwohl, 2002). In our case each learning outcome is represented by the so-called data sentence, which is composed of a constant noun prefix, Bloom's taxonomy action verb and sentence (e.g. student shall be able to describe the principle of linear regression).

The third phase provides vertical harmonization, which consists of verification and further discussion within the individual module under supervision of the responsible guarantor. The fourth phase brings the process of horizontal harmonization, which consists of follow-up discussions across all modules under the management of supervisors. The fifth phase entails the creation of educational content according to the defined learning outcomes.

The authoring team, consisting of guarantors and teachers of Mathematical Biology study field, proposed a set of fundamental knowledge and skills known as GMER (Global Minimum Essential Requirements). This type of outcomes defines what students are expected to know, understand and/or be able to demonstrate at the end of a period of learning, typically as a graduate. This concept has been already used by a number of academic institutions, especially in medical education (Schwarz and Wojtczak, 2002), (Zhang et al., 2002). The idea of learning outcomes helps determine what teachers are supposed to teach, what students are expected to learn and what knowledge all alumni must have. It provides a correctly compiled and balanced curriculum across selected study fields. The management of Mathematical Biology is currently delegated to 21 teachers who interact with the study harmonization and streamlining process in different roles and provide feedback to the developers of the ICT mashups from which the web-oriented platform is composed.

Table 1: Summary of Mathematical Biology study field.

Total number of modules	5
Total number of courses	26
Total number of learning units	261
Total number of learning outcomes	1281
Total number of teachers and guarantors	21

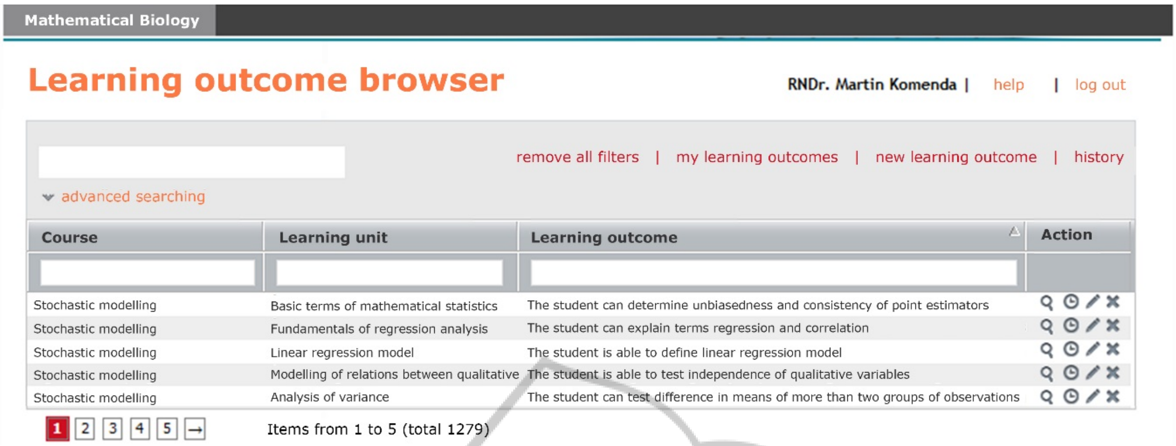

Figure 3: Overview of learning outcomes with the use of data grid component.

One part of the platform, which was developed and tested, is called Learning outcome browser and it is based on the data grid component (see Figure 3). It allows the users to access the data in a well-arranged form and offers the possibility of applying advanced search and filtering based on selected search parameters. Thus, it provides an easy, clear and user-friendly way of managing the curriculum, including evidencing all executed operations such as creating, editing and deleting learning outcomes and units. The browser, which enables various views on the curriculum for both teachers and guarantors, is available online after the login process at http://opti.matematickabiologie.cz/.

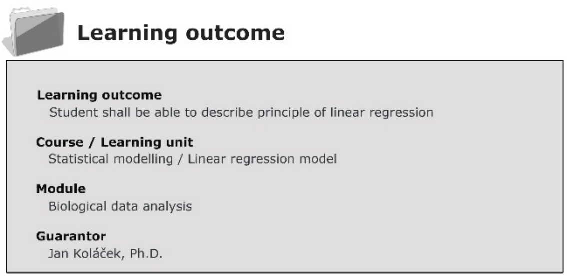

Figure 4: A learning outcome in detail.

The educational materials have been creating according to the presented methodological model and developed platform. It means that the content completely respect the structure of described courses and learning units and every individual topic is always introduced by set of learning outcomes. For the future works, we would like to analyse educational metadata which have been already defined by parametric elements comprising predefined attributes. For instance, selected natural language processing methods and visualisation techniques would be used for the classification of learning units into the classes or clusters, which can discover information rich relations, imperfections and potential overlaps across the chosen field of study. Moreover, we would like to assess the created curriculum from the Bloom's taxonomy perspective and divide all the learning units into cognitive, affective, and psychomotor domain.

5 CONCLUSIONS

In this paper a brand new approach to curriculum planning and management within tertiary education was described. It adopted an outcome-based approach and involved modern ICT technologies in mashups that composed an original web-oriented platform to implement the presented model approach into education. The presented methodology and the platform will help academics in their curriculum reengineering efforts, as it provides a transparent overview of the curriculum structure. Our approach as well as the platform was adopted in practice by senior teachers and professional guarantors within the content inspection of Mathematical Biology field of study. We believe that our model approach is robust enough to be applied with a small set of minor adjustments to any field of study. Further, we also showed how the entire harmonization process is phased to allow avoiding any suboptimal solutions. Unlike the developed web-oriented platform, the implementation of our model approach is fully independent in the particular ICT as well as on the particular field of study to be harmonized.

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