Towards a Competence-Based Course Authoring Tool Supporting Learning Management Systems

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Abstract—To establish a more comparable, compatible, and coherent system of higher education in Europe, the so-called Bologna Process (BP) has been adopted. As a measure to improve comparability, the BP requires that every study path, module, or course has to define a Learning Goal (LG) which is specified by the conveyed competences. Until now, the expectations towards the BP regarding comparability have not been fulfilled because competences are usually described in form of free text and not in standardized terms. The fact that since adoption of the BP more than 10.000 study programs have been created in Germany outlines a trend which demonstrates the need of improved solutions. Regarding comparability, so-called ***Competence Frameworks (CFs)*** with standardized, machine-readable competences are promising tools; therefore, they should be integrated into progressive software infrastructures concerned with creation, management, and execution of study paths, modules and courses. For this purpose, the so-called ***Qualifications Based Learning Model (QBLM)*** has been developed. In this paper, we introduce a general system architecture which is designed for realizing Competence-based Learning IT-infrastructures. Furthermore, the conceptual design and prototypical implementation of a ***Course Authoring Tool (CAT)*** is described which is based on the QBLM and the information-, content-, knowledge-, and learning management platform Knowledge Management Ecosystem Portal (KM-EP). The integration

of the QBLM into Learning Management System (LMS) Moodle which is an underlying subsystem of the KM-EP platform is work in progress.

Keywords—Competence-based Learning, Competence Model, Competence Frameworks, Competence Manager, course authoring tools, LMS, Moodle

1 Introduction and Motivation

Along with the Europe-wide university-reform called ***Bologna Process (BP)*** ([8]; [2]) which started in 1999, the member countries of the European Union made some agreements concerning the comparability and quality of higher-education study programs. As a consequence, each ***Study Program, Module, or Course (SMC)*** has to be provided with academic credit points according to the ***European Credit Transfer System (ECTS)*** [10]. Furthermore, the conveyed qualifications have to be stated and categorized in a determined way by assigning so-called ***Competences***. A binding accreditation process which every SMC provided by a European university or college has to pass ensures compliance of these criteria.

The fact that every SMC has to provide a so-called ***Learning Goal (LG)*** description containing a summary of all conveyed competences, on first sight seems to enable students to integrate a greater flexibility into their curricula. Unfortunately, that expectation did not fulfil; the comparability of learning content has not increased in the degree originally aimed by the BP. As the development of standardized qualifications catalogues is still at an early stage, competences are usually described in form of free text and every faculty, sometimes even every study program, in every university uses its own formulations. This leaves too much scope for interpretation and misunderstandings.

In September 2016, the ***University of Hagen*** (German: Fern-Universität Hagen, in short ***FernUni***) [14] initiated the preparation of an interdisciplinary research cluster which is concerned with the effects of Diversity, Lifelong Learning, and Digitalization on higher education [19]. In this context, progressive approaches for representing competences in a comparable and BP-conform way are of major interest, for example the use standardized machine-readable competences from so-called ***Competence Frameworks (CFs)***, instead of free text. The ***Chair of Multimedia and Internet Applications (CoMMIA)*** [17] at FernUni's Department for Mathematics and Computer Science, a participant in this research cluster, is currently working on this topic, see [25], [27] and [21].

Research projects like ***EDISON*** [7], a 2-year project which started in September 2015 with the purpose of accelerating the creation of the Data Science profession, already perceive CF-based competence specifications as an integral part of a profession profile and corresponding study programs. FernUni's CoMMIA through its associated ***Research Institute for Telecommunication and Cooperation (FTK)*** [15] is a participant of the EDISON project which has several thematic intersections with the above-mentioned research cluster.

In the remainder of this paper, we will outline the starting points for our work by means of a problem statement, corresponding objectives as well as our research questions and approach. At first, we will introduce the relevant state of the art in science and technology. Furthermore, we will present our overall and detailed architectural approach to realise a prototype of a ***Competence Based Learning (CBL) Course-Authoring Tool (CAT)***. The implementation of a prototype in a first version is discussed in section 5 and a first initial evaluation in the pan-ultimate section. The paper will conclude with some reflections and conclusions as well as an outlook onto the remaining future work.

2 Problem Statement, Research Questions, Objectives and Approach

Students' hope for greater flexibility and location-independent planning of their individual curricula unfortunately did not fulfil; some publications, like, e.g., [30] express the frustration about the lack of impact of the BP. Faculty members are disappointed as well, especially those who are responsible for acceptance procedures and therefore have to judge about equivalence of certificates issued by different educational institutions. Many reasons for this dissatisfaction are of political and administrative nature. Furthermore, the fact that the number of accredited bachelor and master's study programs is rapidly growing makes it hard to keep an overview. According to [23], there are more than 10.000 study programmes only in Germany at the beginning of 2016. The consequence for acknowledgment procedures is obvious. However, there are also technical deficits, particularly in the context of learning goals and competences: they are usually specified in form of free text and leave a large scope for interpretation and misunderstandings, because every faculty or institution uses its own words.

This article is concerned with some important research aspects which have not been covered in adequate detail by our former publications. The main question is, how a technical solution must be designed to support teachers in higher education with a competence based CAT?

Replacing free-text LG specifications with competences from standardized, generally admitted ***Competence Frameworks (CF)*** or taxonomies can be a relief for those faculty members who are responsible for acknowledgement procedures and decisions about equivalence of examinations passed in different study programs and institutions. From a student's perspective, such LG-descriptions offer a reliable fundament for identifying and comparing suitable SMCs. Therefore, they contribute to increased flexibility and a greater scope of design for personal study programs and ***Learning Plans (LPs)*** [33]. Consequently, a progressive, BP-compliant learning concept has to include a strategy for equipping SMCs with LGs which consist of selected qualifications from widely applicable, machine-readable competence catalogues. Software solutions concerned with creation, management, organization, and execution of SMCs are therefore required to offer capable and user-friendly support for such approaches.

Besides internal processes concerned with data management and exchange (for details see [28]), ***Graphical User Interfaces (GUIs)*** have to be developed, for example, a ***Competence Manager (CM)***, an improved ***Course Authoring Tool (CAT),*** and other utilities for managing LGs and LPs. Tutors, teachers, and professors - especially when they are not working in the field of information technologies - need to invest a distinctively high amount of time to get familiar with every piece of unknown software in their scholastic infrastructure. They should not only be embraced by the change but feel inclined to try out new features without being confronted with having to learn every single feature of bulky platforms and software-packages, such as the LMS and LCMS *Moodle* [18] which is in the focus of our work described in this paper. As a consequence, an easy to learn and use CAT for producing content for LMSs would not only help to save time and trouble for the teachers, but would also help *Higher-Education Institutions* (HEIs) to safe monetary resources in training teaching assistants.

Furthermore, the course authoring process should be supported by competence- and taxonomy-based ***Content Syndication*** functionality and ***Recommender Systems (RS)*** - this topic area is being researched at the moment and will be presented in a future paper. RS could support the creation and modification of individual learning plans and study programs: depending on the gap between a student's existing ***Competence Profile (CP)*** [31] and his personal LG, the system can be scanned for appropriate learning content. If the available ***Competence-Relevant Learning Elements (CRLEs)*** are distributed over multiple software infrastructures and institutions, cross-system interoperability is necessary as well.

With regard to the above-mentioned research questions, the concept of ***Qualifications Based Learning (QBL)*** has been developed ([25]; [27]; [28]). In [28], the ***Qualifications Based Learning Model (QBLM)*** has been introduced, which can both be used for direct implementation and for serialization into an xml-based exchange format. Our former publications use the terms ***Competence Based Learning (CBL)*** and ***Competence Based Learning Model (CBLM)***, but as the approach is designed to support qualifications frameworks like the EQF [9] and the e-CF [6] which divide qualifications into competences, skills, and knowledge, the terms QBL and QBLM are more accurate. Based on the QBLM, advanced search- and comparison-algorithms can be implemented, followed by RSs for supporting course creation and the development of personal learning plans. Besides competence frameworks, other types of standardized qualification representations, in the following introduced as an application of domain-oriented ***Taxonomies***, are considered. For best possible content syndication going beyond the level of a single CF, the QBLM supports connections between elements from different frameworks and corresponding domain taxonomies.

Our approach is the use of the QBLM as a basis for a conceptual design and prototypical implementation of a ***CBL Course Authoring Tool (CBL CAT)***. In a first step we have to identify suitable technologies, which offer competence-based CA and identify the lack to our requirements.

3 State of the Art and Technology

The CBL CAT and the underlying QBLM are inspired by results of former research projects, which already worked on related problems and offer interesting thoughts or even partial solutions for our objectives. They are introduced within the following sections, for detailed information see our previous publications ([25]; [27]; [28]; [21]; [34])**State of the Art**

Subsequent to the BP, some promising approaches have been made to define qualifications standards in the European region:

1. The ***European Qualifications Framework for Lifelong Learning (EQF)*** ([9]; [11]; [12]);
2. The ***European e-Competence Framework (e-CF)*** ([20]; [19]);
3. The 2012 ***ACM Computing Classification System (ACM CCS)*** ([1]; [19]).
4. The ***Personal Competence Domain Model (PCDM)*** ([31])

3.1.1 European Qualifications Framework for Lifelong Learning (EQF)

The EQF ([9] & [11]) has been established in 2008 by the European Parliament and Council with the goal to improve the comparability of qualifications in the context of the BP. It is compatible to the ***Qualifications Framework in the European Higher Education Area (QF-EHEA)*** which has been introduced within the BP, and expands it with support for non-academic graduations and continuing education. The EQF serves as a reference framework for national or sectoral qualification systems and defines eight general qualification levels, which are related to standardized graduations and certifications; for example, the levels 6, 7 and 8 comply with Bachelor, Master and PhD. Each level specifies criteria for three qualification types: competence, skill and knowledge. In recent years, a large number of EQF-compatible National Qualifications Frameworks (NQFs) [13] have been developed and mapped to the structure and difficulty levels of the EQF; for example, the German DQR [3]. NQFs can be compared by using the EQF as a kind of middleware or mediator; a tool for comparing 14 EQF-compliant NQFs is available in [13]. If the qualifications conveyed by national graduations and learning programs, academic and non-academic, are specified in an EQF-compatible way, they can be compared Europe-wide on this basis.

3.1.2 European e-Competence Framework (e-CF)

As stated above, the EQF defines a raster for classifying learning outcomes; it does not describe or grade any concrete competences or study programs. A promising approach of international dimension is the ***European e-Competence Framework (e-CF)*** ([6]; [20]) which concentrates on the domain of ***Information and Communication Technology (ICT)*** and is regarded as the first sector-specific implementation of the EQF. Its development started in 2005 and is a continuous process until today; an overview of the recent version v3.0, which has been released in 2013, is provided by

the e-CF profile tool [21]. The 40 competences defined by the c-CF are divided up into five areas representing the ICT-Business Processes Plan, Build, Run, Enable and Manage. Terms like competence, skill, and knowledge are interpreted in an EQF-compliant way and the ***Proficiency Levels (PL)*** specified by the e-CF can be mapped to EQF-levels.

3.1.3 The 2012 ACM Computing Classification System (ACM CCS)

The 2012 ***ACM Computing Classification System (ACM CCS)*** ([1]; [19]) is a de-facto standard for semantic annotation in the domain of Computer Science, especially for semantic web applications. The first version was published in 1964, the last one in 2012 by the ***Association for Computing Machinery***. The ACM CCS offers a poly-hierarchical taxonomy with over 2000 terms divided into 13 main categories.

3.1.4 The Personal Competence Domain Model (PCDM)

The so-called ***Personal Competence Domain Model (PCDM)*** ([31]; [20]) has been developed in the scope of the ***TenCompetence Project*** with the goal to support competence-based learning scenarios. The TenCompetence Domain-Model is divided into four areas: Learning resources, learner performance, modelling of competences, and the learning network. [31]

In our former publications ([25]; [21]), the PCDM is analyzed in more detail. Some essential elements of our QBL-concept cannot be realized with the PCDM, but it is regarded as an excellent fundament for the Qualifications Based Learning Model (QBLM) which provides the required modifications and extensions.

3.2 State of Technology

A few software systems already offer basic support for competence-based approaches, but not with the functional range demanded by our concept. Open-source solutions which offer partial solutions for our objectives might be appropriate starting points for prototypical implementations:

3.2.1 The Knowledge Management Ecosystem Portal (KM-EP)

The ***KM-EP*** [23], [16] is an advancement of the Educational Portal toolkit, a ***Typo3***-based [29] learning platform originally developed by the software company ***GLOBIT*** [16]. The further development is conducted by the ***Research Institute for Telecommunication and Cooperation (FTK)*** [15] in the Horizon 2020 Research and Innovation Action ***RAGE*** [22]. For a more detailed introduction and discussion of the KM-EP see [25].

A wide variety of useful information-, content-, knowledge-, and learning management features is already provided by KM-EP until now, including a web-based, user-friendly course authoring tool called ***KM-EP CAT***.

One of the most attractive qualities of the KM-EP CAT is its intuitive and web-based user interface, which immediately enables users to start their creative approaches towards innovative developments. This is a solid basis to engineer further tools for meeting one of the key-goals of the new authoring tool project: user friendliness.

Another important feature coming with the KM-EP CAT is that there are ready-made course templates, which can be used and extended instead of starting a course design from scratch. Users with little knowledge about the bits and pieces of computer systems or virtual-learning platforms might immediately be enabled to design their online-courses without further learning overhead involved. Instead, they can fully concentrate on contents or didactical strategies without getting lost by having to read bulky and difficult to follow user manuals. Furthermore, the KM-EP CAT contains services for creating courses with competence information. Another important advantage of this solution is that such creations can be transferred to the ***Learning Management System (LMS)*** Moodle [18] with a single mouse-click.

3.2.2 The LMS Moodle

Creation and execution of online courses and learning units have to be regarded as separate issues, even though platforms like ***Learning Management Systems (LMS)*** offer tools for both purposes. Applications like the KM-EP CAT concentrate on the authoring aspect which means that an appropriate runtime environment is required and the learning content has to be transferred to it. As the system of choice for course execution, we decided for the ***LMS Moodle*** [18] which since version v3.1 (published in Jul. 2016) supports competences and competence frameworks in a basic way [5]. Moodle is open source, so adjustments and extensions can be made without raising license problems. It is used by more than 80 millions of persons and according to [35], a study from the Sommer 2016, it was the most-used LMS at German universities. Furthermore, our main use case scenario is concerned with the virtual learning environment at the ***Distance University at Hagen (FernUni)***, where Moodle is set as the default LMS. In our previous publication [28], Moodle has been described in more detail.

3.3 Remaining Challenges

Motivated by the BP, an innovative strategy for improving the comparability of CRLEs based on standardized competences has been developed. An integral part of this concept is the ***Qualifications Based Learning Model (QBLM)***, a domain class model for representing competence-related information, which is intended as a further development of the PCDM. The QBLM, our fundament for prototypical software solutions, will be implemented in form of extensions for common open-source tools.

With Moodle and the KM-EP, two appropriate open-source basis systems for prototypical implementations have been identified, see sections 3.2.1 and 3.2.1. Both systems already offer a broad variety of capable QBL-features which in the case of a standalone-solution for our QBL-concept would have to be re-implemented at a considerable expense. In comparison, the effort for implementing plugins for the above-

mentioned systems seems to be significantly lower, although in the case of Moodle, the elements of the QBLM have to be mapped to existing data structures.

Like Moodle, the KM-EP offers capable authoring and management tools for courses, learning content, and knowledge resources. Some basic functionality for semantic tagging is already provided: knowledge resources can be tagged with elements from taxonomies, for example, the ACM CCS described in section 3.1.3. To suffice our QBL-concept, this tool has to be adapted for supporting relations between CRLEs and competences from CFs. On the basis of the QBLM as domain class model, suitable services and user interfaces for handling competences and competence-related data have to be implemented.

4 Conceptual Design

The first section of the conceptual design is concerned with the domain class model, which underlies the KM-EP CAT. It has to allow for competence management and competence based course authoring.

The concept of Qualifications Based Learning (QBL) assumes that competence data have to be accessed by diverse software components of an educational institution's IT-infrastructure, including the CBL CAT and the LMS. Therefore, a distributed software integration architecture is required which allows for exchanging CBL-data between the involved systems. In section 4.2, an overall solution is presented.

CBL-support on the KM-EP side requires services for handling competences, bundling them to competence profiles and connecting them to CRLEs. Later, recommender systems for simplifying CRLE-authoring processes can be considered.

Finally, some design aspects of the competences based KM-EP CAT are outlined.

4.1 Qualifications Based Learning Model

To realize competence-based authoring tools, we need a domain class model for representing competences and competence-related data. In [28] the so-called ***Qualifications Based Learning Model (QBLM)*** is introduced (see Fig. 1), which has been developed in the context of our QBL-concept described in ([25]; [27]; [34]) and therefore matches with our requirements. The QBLM is a further development of the PCDM (see section 3.1.4). Our former publications use the terms ***Competence Based Learning (CBL)*** and ***Competence Based Learning Model (CBLM)***, but as the approach is designed to support qualifications frameworks like the EQF and the e-CF, which divide qualifications into competences, skills, and knowledge, the terms QBL and QBLM are more accurate.

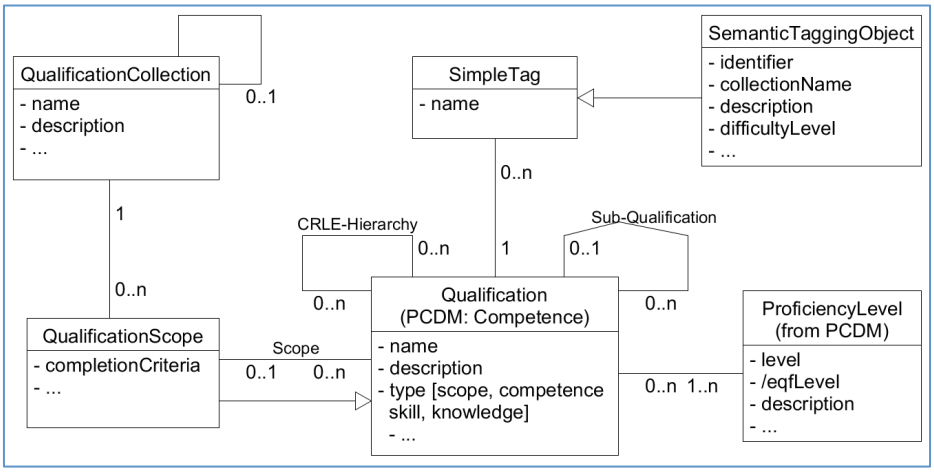

Fig. 1. QBLM - Generalized Version

Providing support for standardized qualifications catalogues like competence frameworks is a major goal of the QBLM; a core requirement has been the representation of the European e-Competence Framework (e-CF) described in section 3.1.2, which concentrates on the field of Information and Communication Technology (ICT). The generalized version of the QBLM (see Fig. 1) can be applied for a variety of EQF-compatible (section 3.1.1) CFs; furthermore, it includes structures for connecting qualifications from different CFs and taxonomies like the ACM CCS (section 3.1.3).

The class ***Qualification*** represents all types of qualifications like competences, skills or knowledge. To increase the informative value of CFs and to offer best possible conditions for content syndication functionality and recommender systems, the QBLM has to be provided with elements for enabling connections between competences and qualifications from taxonomies. Simple terms can be represented by ***SimpleTag***-instances, but usually taxonomy-elements are represented by the class ***SemanticTaggingObject (STO)***. Each Qualification can have on ore more ***ProficiencyLevels (PL)*** and can be connected to one or more CRLEs, e.g. ***s***tudy programs, modules, courses, learning activities or knowledge resources***.*** Hierarchical structures between Qualifications are possible through ***Sub-Qualifications***. The ***QualificationScope (QS)*** defines the "maximum qualification", which specifies a fixed pool of available PLs and ***Skills and Knowledge Examples (SKEs)***; furthermore, the QS offers the opportunity to add completion criteria. A ***Qualification Instance (QI)*** contains a subset of the SKEs and PLs which are available within the corresponding QS. QIs are the elements which in the meaning of our QBL concept have to be connected with CRLEs and personal user profiles.

4.2 Conceptual Software Integration Architecture

Currently, our prototypical implementation concentrates on the two established open-source learning platforms Moodle and KM-EP which have been described in the sections 3.2.2 and 3.2.1. Besides fundamental CBL-support, the scheduled extensions will provide appropriate interfaces for exchanging CBLM-based courses and learning activities. In the described constellation, the KM-EP's ***Course Authoring Tool (KM-EP CAT)*** is designated for creation and modification of courses, which have to be transferred to and executed by the LMS Moodle. Our former publications ([25]; [27]; [28]) discuss this task-sharing in more detail and propose a platform-specific architecture which is the fundament for the ***Software Integration Architecture*** displayed in Fig. 2.

Realizing the KM-EP related challenges means to extend the KM-EP with support for QBLM-compliant data structures. First of all, we need a ***Competence Manager*** for editing competences; moreover, it has to provide services for bundling competences to competence profiles. Furthermore, the CAT has to provide functionality for creating and modifying connections between competence profiles and courses. In Fig. 2, an overview of the platform-specific architecture is displayed; software components which have to be created or modified are highlighted in green. Their design and implementation will be described in the following sections.

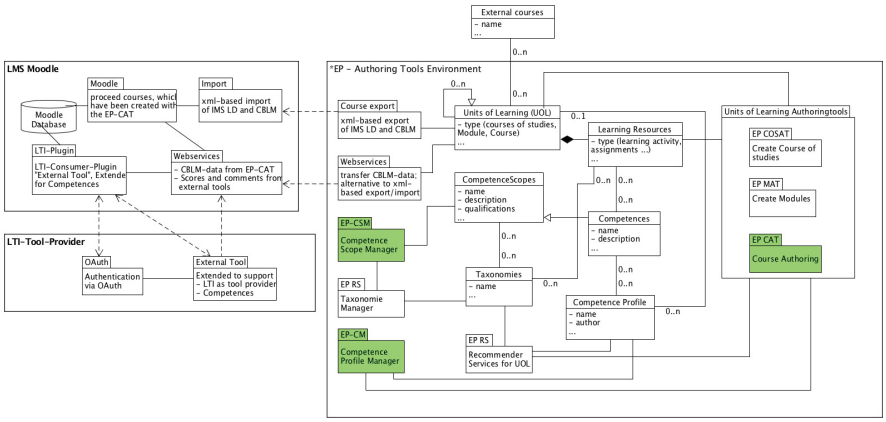

Fig. 2. Use Case Scenario FernUniversität - Software Integration Architecture

4.3 Competence-Based Course Authoring

This section outlines both the conceptual design of the CBL CAT and the required services to handle competences and competence profiles. We identified four perspectives of usage and introduced correspondent roles:

- The **Competence Manager** who works with Competence Management Services like creation of new frameworks or competences.

- **Users of Competence Frameworks** who can see information about existing frameworks or competences and can build new competence profiles.
- **Teachers** or **Trainers** can create and manage courses but they are also authorized to assign a competence profile to a course. Furthermore, they can build new competence profiles.
- **Learners** can create their own Learning Goals in form of a competence profile, search for courses of interest, enroll into courses, and access them.

4.3.1 Competence Manager

The **Competence Manager** is a tool for designing and managing competence frameworks. The underlying domain class model is based on an early, e-CF-specific version of the QBLM, which is fully compatible to the generalized version displayed in Fig. 1. In [28], the development process of the QBLM is described in detail. Fig. 3 shows the UML class diagram of the Competence Manager.

The ***CompetenceScope*** corresponds to the QS from the QBLM and defines the "maximum competence", which specifies a fixed pool of available ***Proficiency Levels (PLs)*** and ***Skills and Knowledge Examples (SKEs)***. Through the possibility to select individual SKEs from a CompetenceScope, a huge number of different concrete competences can be created on the basis of a CompetenceScope. Furthermore, semantic information can be added to a CompetenceScope in the form of taxonomy terms (named categories in the class diagram); they are treated as additional information and cannot be (un-)selected for concrete competences. Each CompetenceScope is assigned to a ***CompetenceCollection*** which can either consist of competence scopes or sub-collections; a CompetenceFramework would be treated as root-CompetenceCollection. This structure allows the design of frameworks with multiple layers or dimensions. Competences can be assigned to one or more ***CompetenceProfiles***, for example, within a Learning Goal or Condition Profile.

4.3.2 Competence Profile Manager

The ***Competence Profile Manager***, a software component which allows users to create and manage competence profiles, is displayed in Fig. 4. A ***CompetenceProfile*** is a set of concrete competences which can be used to specify, for example, a learning goal of a course, a precondition for participation in a course or test, a user's individual competence profile or a job advertisement. The ***ProfileUseCase*** handles the use of a *CompetenceProfile*, because one profile can be used for many targets in application scenarios. For example the same CompetenceProfile can be used from one course as a learning goal and from another one as preconditions. Each use case will describe a utilization of a profile.

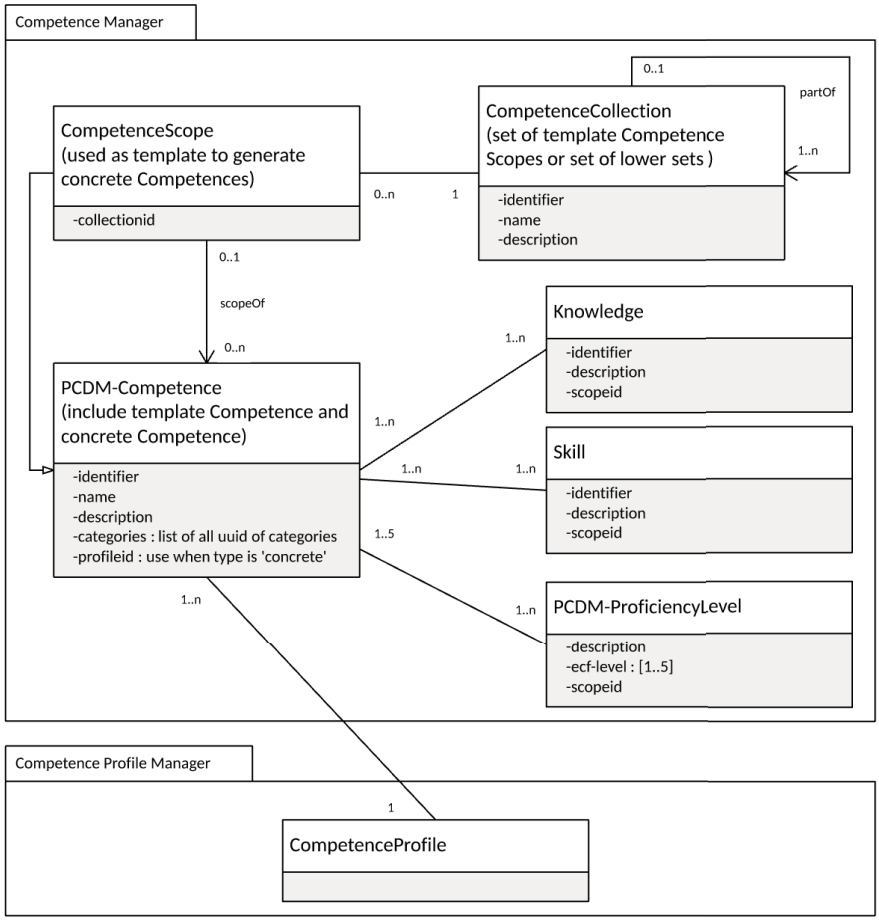

Fig. 3. Competence Manger - UML class diagram

4.3.3 Course Manager

From the perspective of the KM-EP, each course can be regarded as learning content of an information-, content-, knowledge-, and learning management system; each user can search for all courses from the explore page as the starting point. To each *Course*, a competence profile can be assigned as its precondition and/or goal. This relation should be ensured by a profile usage.

The creation of courses and activities will be maintained and managed by the KM-EP. The data exchange between the KM-EP and Moodle is realized through web services.

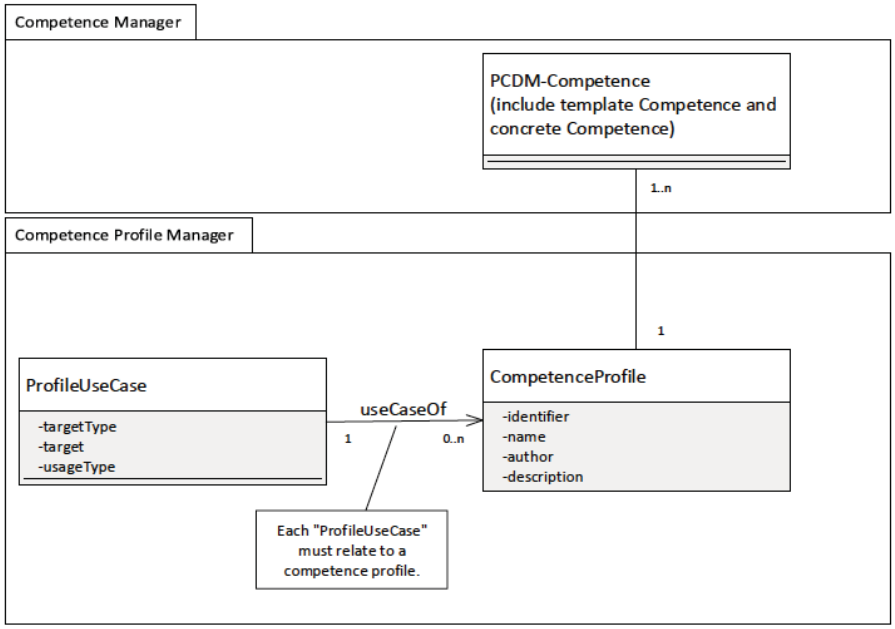

Fig. 4. Competence Profile Manager – UML class diagram

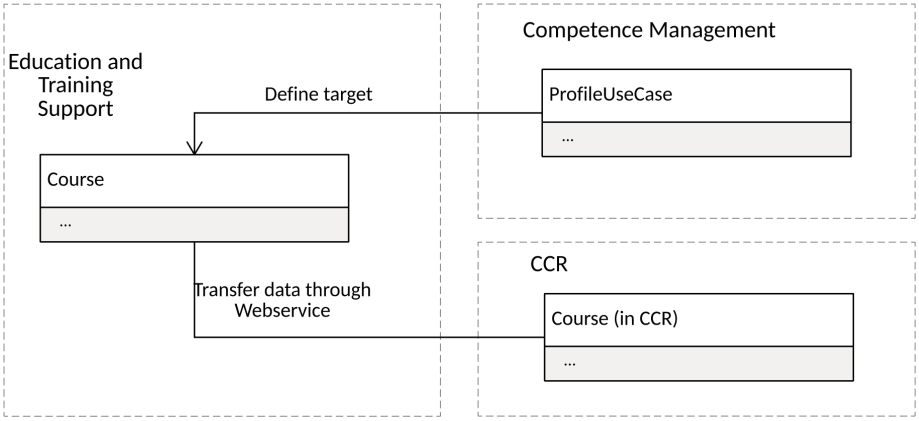

Fig. 5. Course Manager - UML class diagram

5 Proof of Concept Implementation

After inspecting the afore mentioned use cases and their corresponding object-oriented models, we will now focus on the implementation of the prototypical system. In the following, a prototypical implementation will be described. The basis system for our CBL-tools is the **KM-EP** which is based on Typo3 [29], Moodle [18]**,** and

MySQL [19]. This means, that the additional functionality has to be introduced in form of extensions and plugins.

5.1 Course-Authoring Tool

The KM-EP Typo3-extension ***Ftk_sto*** is the main component of the KM-EP's learning portal and can be accessed both by teachers and by learners. For teachers, it provides course creation functionality and for learners, it offers tools for searching and enrolling into courses. Ftk_sto supplies four plugins for front-end pages. The CAT KM-EP Typo3-plugin (see Fig. 6) enables course authors, who are not LMS- and Moodle-experts, to comfortably create courses with associated resources and assignments. In addition to the standard course creation process, the CAT supports course templates, which can be used as starting points. In a first step, the course is initialized as a clone of the template; the author just then has to customize it. The course creator can easily add a new module of many types (activities and knowledge resources) to a course section. Publications and presentations, which are stored within the Ecosystem, can be used as learning material of courses.

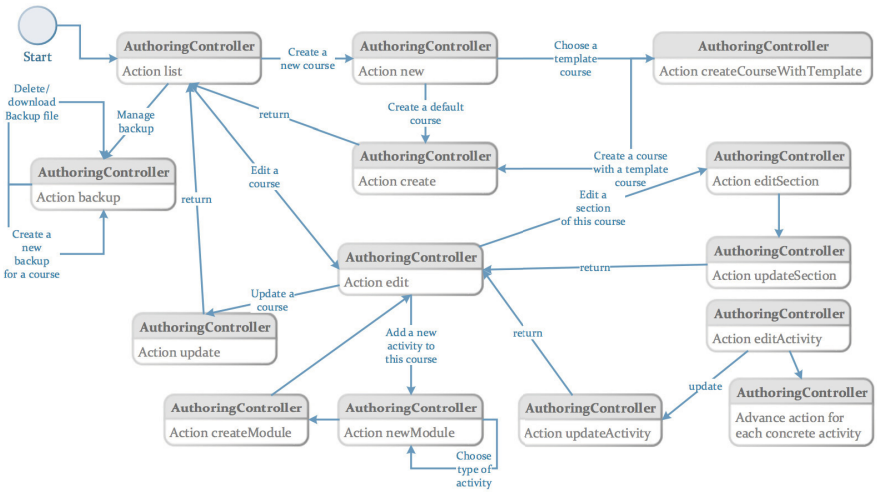

Fig. 6. The KM-EP CAT Typo-3 plugin

The KM-EP Typo3-plugin ***Course Manager*** will allow a user to add existing Moodle courses to the KM-EP. The third KM-EP Typo3-plugin ***Course Display*** allows learners to see information about a course and to enroll into this course. Furthermore, the learning interface of Moodle can be embedded into the KM-EP by using an iframe [35]. This enables learners to access all course-related activities, materials, and collaboration tools without having to leave the KM-EP.

5.2 Competence- and Profile-Management

The KM-EP Typo3-extension ***Ftk_competence*** contains two main plugins, the C***ompetence Manager*** and ***Profile Manager*** which contain the eight objects described in 4.3.1and 4.3.2 and two simple plugins to display and describe CP. Besides object modelling, we should keep one's mind focused on the four plugins of this extension and their controllers. The first plugin ***Competence Manager*** (Fig. 7) enables users to design a competence framework, whose competences later can be used to create competence profiles.

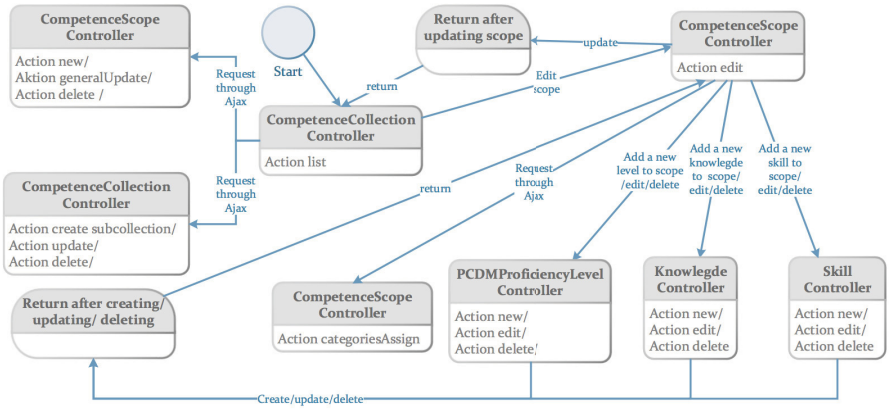

Fig. 7. Workflow of the Competence Manager

Through messages to the controller *CompetenceScope*, a competence scope can be created or deleted. Besides this, the controller will provide a functionality to edit a competence scope. Categories (terms from taxonomies) can be assigned to a scope and furthermore, with the three controllers *PCDMProficiencyLevel*, *Knowledge*, and *Skill,* QBLM-elements like PLs or skill/knowledge examples can be added to a competence scope.

The second new KM-EP Typo3-plugin, the ***Profile Manager*** (Fig. 8), uses the controller *CompetenceProfile* to display a list of all profiles and to create, edit or delete a profile. Besides editing general information of each profile, this plugin offers services for adding competences with selected levels, skill examples or knowledge examples.

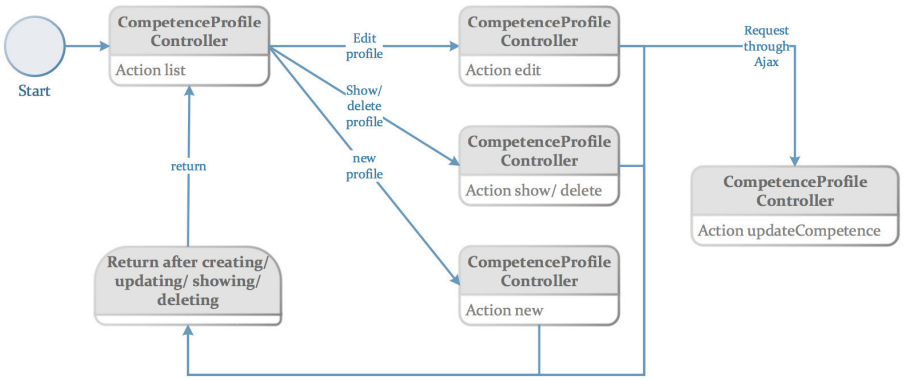

Fig. 8. Profile Manager - Interaction Diagram

The third new KM-EP Typo3-plugin ***Profile Display*** is used to display a competence profile. For example, a student who is interested in a course's learning goals or preconditions for participation, will use this feature. The forth plugin ***Tool*** is a simple plugin to describe all profiles and competence frameworks.

6 Initial Evaluation

An initial qualitative evaluation of the prototypical implementation has been accomplished, in form of cognitive walkthroughs by domain experts in the field of education in Computer Science. The main goal of the evaluation was to estimate the productive capacity of the implementation and to orientate the future development.

As a real-world user experiment they created the exemplary sample course *Informationsvisualisierung im Internet* from the CoMMIA. In a first step the CAT is evaluated with respect to its services to use templates, customize a new course, and add learning resources and assignments.

In a second step the experts constructing a competence framework with the competence manager and tests the services to create and manage competences. As real world example the competences from the European e-Competence Framework (see 3.1.2) are used and mapped into the CBLM-based competence manager. Besides the creation of competences, categories (terms from taxonomies) from the ACM CCS (see 3.1.3) are added. Based on the created competences framework two competence profiles are created and assigned to the new course. First a profile as a learning goal and a second one for the pre-conditions.

The results from the initial evaluation are errors and suggestions (e.g. safety queries) which led to an improved version of the CAT. After the evaluation a course creation manual and two additional courses for different scenarios (*Academic Teaching and Training* and *Continuous Professional Education*) as reference implementations was generated. Both additional courses will now be evaluated more formally by experts within the context of the research project EDISION.

7 Summary and Future Work

In this article, an authoring tool for competence-based courses and learning resources has been presented which prototypically implements the CBL-concept published in ([25]; [27]; [34]). The fundament for representing and exchanging competence data is the ***Competence Based Learning Model (CBLM)*** which is described in [28]. Motivated by the Bologna Process and the lack of comparability regarding verbally described competences, our CBL-approach proposes to equip courses and learning activities with standardized, machine-readable information about the conveyed qualifications. In the state-of-the-art-section, existing competence frameworks and domain taxonomies have been described. The European e-Competence Framework (e-CF) has been identified as an important representative with all typical properties of a qualifications' collection, and the LMS Moodle and the Knowledge Management Ecosystem Portal (KM-EP) have been selected as starting points for our prototypical implementations.

In the conceptual design section, we shortly introduced the CBLM, our software integration architecture and the three basic components of our KM-EP-extension: **competence manager**, **competence profile manager** and the **CAT.** The realization of the CBL CAT prototype is described in section 5.

After the initial evaluation described in this paper and the more formal evaluation by experts in the EDISON project, the improved CAT will be used by real users in the context of the RAGE project. Based on the created manual, we would like to train users and make experiments with them while they build their own courses. By tracking the users during the experiments, we measure the effectivity and performance of the CAT. On the implementation side, the KM-EP CAT will be extended with services to create and handle study programs and the associated modules; the results will be presented in a later publication. Future works are the competence-based recommender services to support authors during course creation and a version management for the competence manager extension.

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