Development of authoring tools for online-courses with assignments

***Benjamin Wallenborn**, **Matthias Then**, **Birgit R. Ianniello**, **Matthias Hemmje**, ZMI FernUniversitaet in Hagen Germany*

ABSTRACT. Today's workforce faces a dynamic world with changing occupations, tasks, and demanding technologies – forcing people to adapt their skills and competences permanently to new requirements. Many achieve further qualifications in parallel to their working careers, often without adequate support or suitable educational institutions. Competence-based learning (CBL) aims for including formal and informal learning into everyday life: at the workplace or during leisure activities. This paper is concerned with some of the most important aspects of CBL – course content-authoring and assignments while making effective use of an integration architecture fostering the interoperability of hybrid e-learning solutions including legacy software. Such modern scenarios ask for interoperable software solutions which effortlessly integrate existing e-learning infrastructures and legacy tools with innovative technologies while being cognitively efficient to handle, in order to seamlessly enable prospective users to use them. We introduce our approach of developing a competence-based course authoring and assignment support-software, bridging the gaps between Moodle and established assignment infrastructures by embedding existing legacy tools via LTI.

KEYWORDS: *Competence-based Learning, Course authoring tools, Interoperability, HEI, LMS, LCMS, Learning information and content management, LTI, Moodle, Moodle plugins, Hybrid tool solutions*

1. Introduction and motivation

The world in which we live and work nowadays is highly dynamic with respect to changing job profiles and new professional task challenges as well as facing innovative technologies. This means, that people have to learn and adapt their skills and competences permanently to new

requirements and competence levels of changing work environments. Traditionally, the first formal education and training track ends after school and – unless an academic path is chosen – offers vocational training as a second track in order to prepare for a professional career. However, there is usually no additional solution for lifelong learning, i.e., a tertiary track of follow-up education after completing vocational training is missing. For this reason, innovative learning scenarios emerge within Higher-Education Institutions (HEIs) and providers of so-called Continuous Professional Education (CPE). These new educational scenarios require modern software solutions being supported by, in some cases life-long, educational e-learning infrastructure. As new features in learning-software can lead to the production of additional ambitious ideas for such demanding teaching and learning scenarios, the development of corresponding e-learning software solutions constantly progresses. A distinctive need for transparently usable tools to support creative learning-content production and consumption approaches of their users can be identified.

Many people achieve further qualifications, generally in parallel to their professional working careers through such a tertiary track of formal and informal education but quite often neither with adequate IT support nor by suitable educational institutions and programs. So-called *Competence-based Learning* (CBL) approaches – as described in more detail in Tencompetence.org (2015) – are aiming at solving this problem by offering both, formal and informal learning in everyday life, at the workplace, or during leisure activities. As an introduction to CBL, and as the motivation for the remainder of our work introduced in this paper, we would like to outline some of the most important concepts of CBL before introducing to the initial research we have achieved through the design and initial development of a course-authoring tool for competence-based learning content involving LTI.

Within CBL, a *Competence* is regarded as the acquired or perceived skill of a person, group, or organization to handle critical events, problems, or tasks in certain situations. An example – in the field of Computer Science education and training – would be the mastering of object-oriented programming techniques. The acquisition, perception or possession of such skills can typically be proven, documented, or certified by self-assessment, informal or formal assessments and feedbacks as well as markings by tutors or automatically by computer programs (Vogten et al., 2007).

A collection of competences to handle diverse problems in different situations is called a *Competence Profile* (Vogten et al., 2007). A competence profile might, e.g., be "Software Developer in C++". Furthermore, competences and competence profiles have their own proficiency level. This approach is targeted to life-long learners and asks for a software which will not only bridge the gap between traditional e-learning platforms and modern *Learning Management Systems* (LMS) solutions like Moodle but also for a thorough support to enable institutions to single out different materials for the creation of new courses outside the higher-education curriculum like, e.g., for accredited or certified courses in CPE.

Our first concrete objective within this overall goal is to develop an innovative course-authoring tool in order to support the generation of e-learning courses, which are provided by and consumed in LMSs. This new authoring-tool should, amongst other functionalities, support competence-based learning through the creation of correspondingly designed, managed courses, including competence-based learning goals and plans, so that the examination results can be evaluated as soon as the learning content has been studied, and the examination part begins.

Furthermore, the system should provide helpful functions like content-syndication during the production-phase of courses or recommendations for fitting learning objects during the process of studying the provided content. In addition, generic interfaces for online learning content repositories

are needed in order to support users in searching for additional, suitable learning resources. Finally, easy to learn and seamlessly usable applications will have to be designed to support the didactically important communication between students and tutors by cognitive efficient learning dialogue interfaces.

2. Problem statement and outline of objectives

In order to support competence-based course-authoring, every course needs to be tagged with a so-called *Learning Goal* (Dspace.ou.nl, 2006) and descriptions of the entry requirements, both to be expressed in terms of competences. These attributes will be described on basis of a competence profile (Vogten et al., 2007). This implies that ways to represent and manage competences as well as competence profiles must be found during our research and development in order to enable tutors, administrators or programs to use, share, and exchange these profiles. On learner's side, functions to investigate and measure the competences, for example, through self-assessments, are needed. In addition, a student has to be enabled to choose a learning goal in form of a predefined competence profile.

A learning goal represents a collection of competences with different levels in form of a competence profile level (Dspace.ou.nl, 2006). Each student may have such a personal learning goal. A so called *Learning Plan* (Vogten et al., 2010) should be generated automatically by the system to close the gap between the existing competences and the learning goals of the student. A learning plan outlines opportunities provided along a series of different learning activities and therefore a track to achieve learning goals; it might as well contain parallel or serial activities. In consequence, this means, that functions to report, assess, or estimate the existing skills and competences of a student must be provided before students start their so-called *Learning Activities* (Vogten et al., 2010). Besides this, tests and quizzes are to be support in the design and authoring of course material to ensure that students have achieved certain competence levels and therefore learning goals (Dspace.ou.nl, 2006). After the successful completion of a course, the learner's competence profile needs to be updated automatically to list the new competences (Vogten et al., 2007). Besides this, the competence-based learning software has to support course authoring in such a way that suitable learning resources will be proposed automatically for every new course, depending on the individuals' learning goals (Vogten et al., 2007). In the ideal case, further learning content-syndication should support the students. This means that, e.g., the learning management system should offer additional courses of interest. To be able to do this, the system needs to be able to assess the gap between the target competence profile and the learning goals. Furthermore, the system needs to be designed to support generic interfaces to support easy searching and accessing of suitable learning resources on- an off-line, i.e., locally stored in a database or distributed in online repositories, e.g., used by the teaching community for course authoring.

3. State of the art and technology

The so-called *Personal Competence Domain Model* (PCDM) (Tencompetence.org, 2015) has been developed in the scope of the TenCompetence project. The PCDM offers possibilities of modelling different learning scenarios with competence-based learning support. Figure 1 displays the UML class-diagram of the TenCompetence Domain-Model. The model is divided into four areas: Learning resources (blue), learner performance (orange), modeling of competences (green), and the learning network that contains the remaining other three areas. (Vogten et al., 2007):

The core elements of this model are so-called *actions* such as editing learning material. Actions are executed through an actor – a student or a tutor – to achieve certain goals like acquiring competences for a chosen profession. Actions always take place within a learning network. Actions consist either of knowledge resources like, e.g., learning activities such as doing quizzes, units of learning like, e.g., reading the course material or so-called *Competence Development Programs* (CDP) (Dspace.ou.nl, 2006). During the execution of different actions, actors produce traces of their performance. These traces can have distinct characteristics, e.g., starting with simple activity logs and not ending with the point of solid learning outcomes. The traces are used to infer the competences a learner has achieved; competences are depending on a situation-related context, and they are connected to the learning network. Different levels of competences are modeled through the proficiency level. An alternative or additional way to find out about the competence of a student is through specific competence assessments.

Competence profiles and competences are combined with a learning network. This set is called a *Competence Map* (Dspace.ou.nl, 2006). Single competences can exist generically for a special domain or only for a community. A so-called *Observer* (Vogten et al., 2007) takes care of the common and formal descriptions of generic competences to make them exchangeable between different learning networks. Communities pass their evaluated competences to the observer and may share descriptions of these competences with third learning networks. Each community decides which competence profiles and competences they would like to request or submit when they make use of the observer.

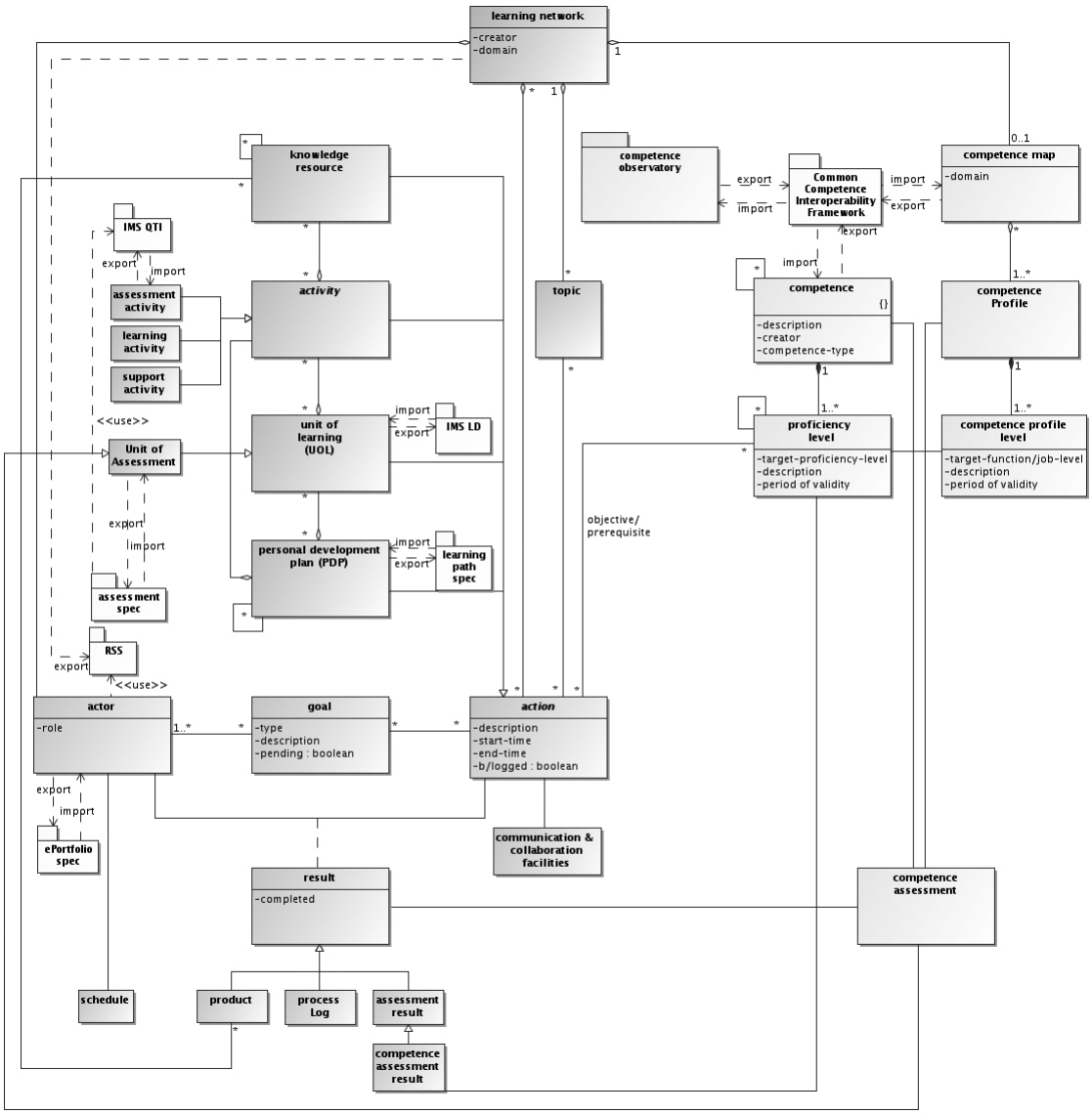

Figure 1. UML Class Diagram of the TENCompetence Domain Model (Vogten et. al., 2009)

The so-called *Personal Competence Manager* (PCM) (Tencompetence.org, 2015) is the technical realization of the TENCompetence Domain Model. The PCM supports individuals, groups and organizations through the lifelong competence development. Besides the learning process itself, it enables students to use a wide variety of functions in the field of network based learning, like the creation of communities, discussion forum or blogs (Vogten et. al., 2009).

The application is open source and divided into two parts: a portal environment – realized with Liferay[1] – and stand-alone system which can be used without the portal. Table1 displays selected portlets (Kluijfhout et al., 2010).

1 http://www.liferay.com/de/

Portlet	Description
Goal Orientation	Shows the existing competence profiles in a learning network that a learner can be achieved. After a learner defined preferences, respective particular competences, the portal can make recommendations for suitable competence profiles.
Assessment	Supporting the learner to identify the gap between already acquired competences and the learning goals.
Activity Navigator	Generates potential learning plans and assisted a learner through different learning-activities to achieve the learning-goal.
SLeD und Astro Player	Runtime environment for units of learning (e. g. a course or lesson).
Social Help	A portlet to contact an expert (dialog function).
Competence Model Editor	An authoring tool to care and create competence model entities.
QTI Editor	Create Question and Tests.
Learning Path Editor	A portlet to create a course of actions. The result is a learning path.

Table 1. The Personal Competence Manager – Selected portlets (Kluijfhout et al., 2010).

Figure displays the persistent entities of the PCM based on the TENCompetence Domain Model. The entities correspond to the elements of the domain model, except the new evidence-entity for the verifications of a student's achievements in particular competences. JournalEntry corresponds to the process log-Element of the Domain Model to track user activities (Vogten et al., 2010).

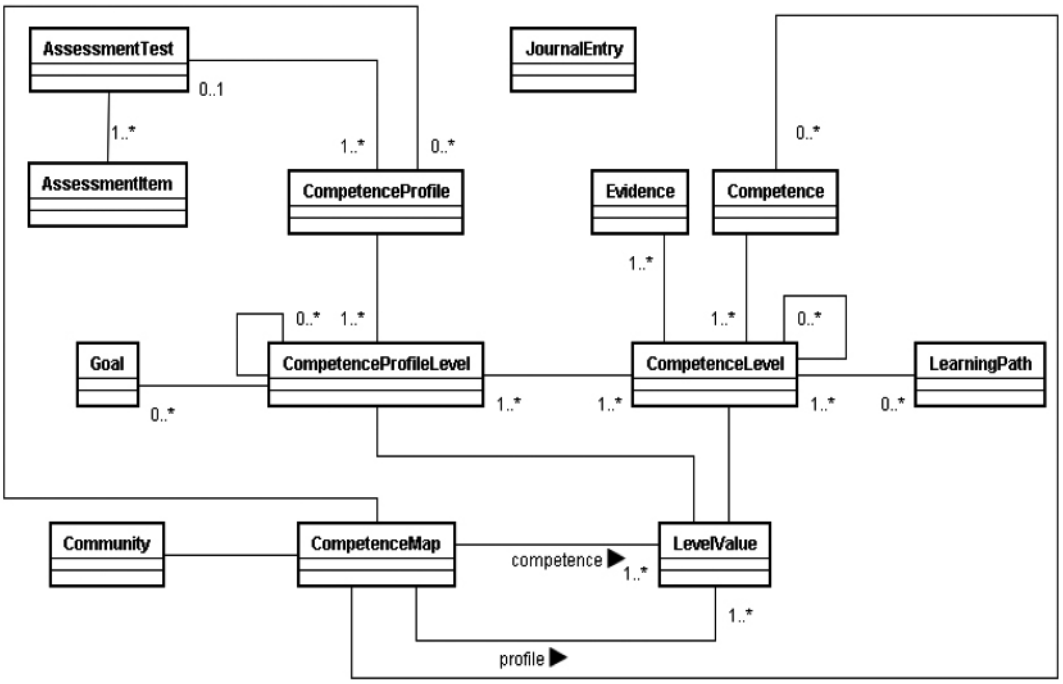

Figure 2. Persistence entities of the PCM (Vogten et al., 2010)

Besides the persistence entities, there are data objects not being ad hoc persistent but turning into persistence entities at runtime (Figure 3). Core entity is a so-called *LearningPath* (Vogten et al., 2010) with at least one CompetenceLevel which students achieve by mastering the path. LearningPaths can consist of three types of clusters:

- Sequence with a fixed order of learning activities
- Parallel, here defined learning activities can be executed simultaneously
- Selection, here students must execute a defined number of activities in random order

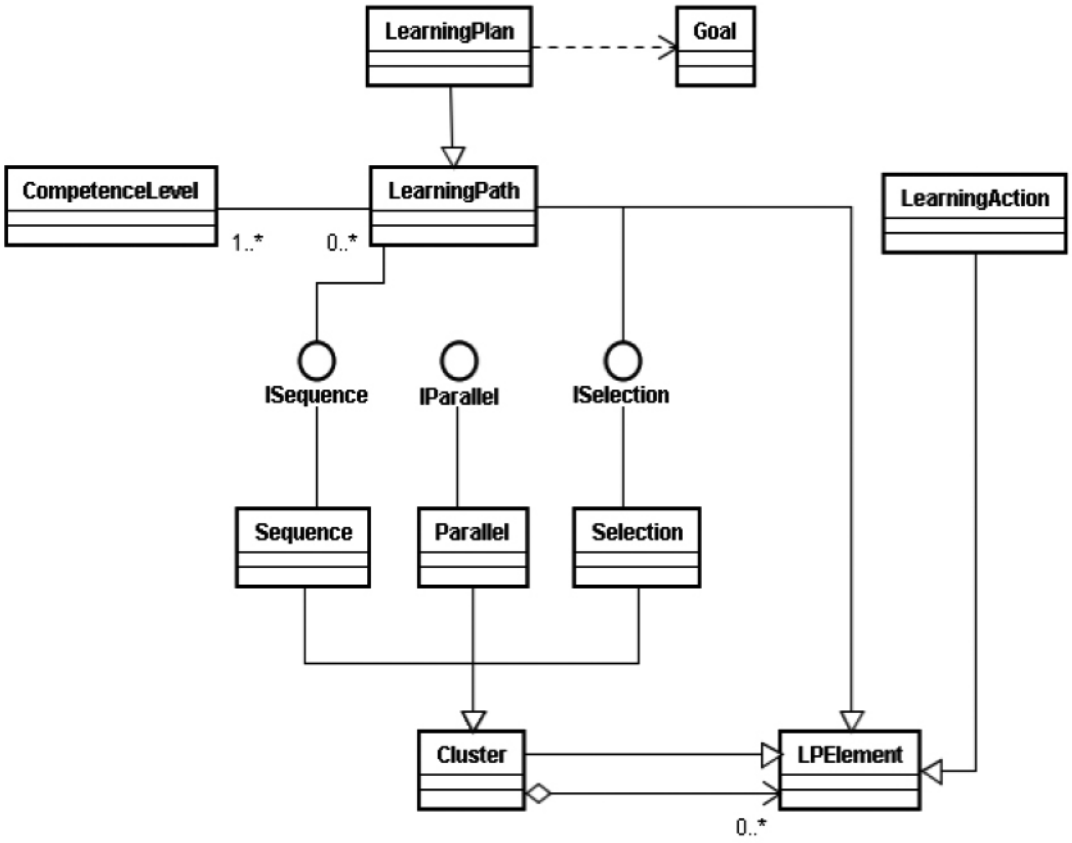

Figure 3. Learningpath entities (Vogten et. al, 2010)

Based on the PCDM and the technical realization, the PCM, we are aiming at designing and developing different tools to support competence-based learning in our legacy infrastructure as well as in integration with Moodle. The first milestone in this road map is to design and implement a LTI-connection prototype. To gain technical expertise with LTI, we analyzed Moodle and its possibilities for integrating external tools, and experimented with the plug-ins to create an exemplary connection between two separate Moodles. This first step will described in the next part.

4. Implementation and legacy assignment software integration

The starting point in this section of the paper is a historical and technical view on our first goal: integrating external e-learning tools, which are partly legacy, with an LMS to realize tests and quizzes. Since Moodle is widely known and used as an LMS and LCMS and other than its proprietary competitor Blackboard (Blackboard.com, 2015) is a so-called open source solution it is the platform of choice for our experimental scenario of course-authoring and execution support for a distance university. Moodle as an LMS and LCMS in combination with several other tools is considered a powerful and at the same time a flexible base system for our research. In a first step, we have started to interview teachers, staff and students at the University of Hagen (German Fern-Universitaet of Hagen: the largest distance-education university of the German-speaking countries, in short FernUni)

in order to identify the needs for – and requirements towards – additional tools to be integrated with the already existing Moodle tool suite.
Originally developed at FernUni's chair of Software Engineering as a project of the so-called *Campus Source Initiative*, the assignment platform *WebAssign* is widely accepted by faculty and staff until today because it supports some particular FernUni-specific workflows. Teachers, mentors and tutors have worked with WebAssign for years, spending a considerable amount of time with developing their assignment scenarios and teaching environments. Therefore, they would not accept its replacement, and WebAssign has to be kept as a legacy tool; it should become integrated with and ideally be embedded in Moodle. In aiming for this goal, exploring the possibilities and features of the so-called *Learning Tools Interoperability* (LTI) standard is a first step. According to (McFall et al., 2014; Developers.imsglobal.org, 2015), LTI specifies a way for integrating learning applications into e-learning platforms. Each university or school which uses a proprietary learning environment or specifically developed tools to foster learning processes can benefit from LTI. The Moodle open source software development community has identified this need and created a plug-in, offering a way to integrate LTI-compatible tools. Therefore, if WebAssign is to be integrated with Moodle, first of all it has to be made LTI-compatible.

IMS LTI specifies a standard way for integrating learning applications such as forums, chat rooms, wikis, assignment tools and video-streaming into platforms such as LMS. In LTI-context, tools are called tool providers, and platforms are tool consumers. The Moodle Community saw the potential of that technology and therefore improved Moodle to support LTI as a tool consumer. The following features are essential for the development of our prototype:

- Launching external resources
- Returning outcomes to the consumer

Within its course model, Moodle supports many so-called *activities*, offering features like assignments, forums, chatrooms or wikis. For launching an external resource via LTI a connection between a Moodle course and an LTI-tool-provider has to be specified; therefor an activity-instance of the type *external tool* has to be created. Its configuration contains authorization parameters as well as essential information like the URI of the resource to connect to. The resource could be, for example, an assignment. When a user enters a Moodle course, the connection is represented by a link to the activity-instance; via mouse click a request for launching the resource is sent.
To secure the access, LTI uses the standard OAuth[2] for authorization. The verification of a request works as follows: On the consumer side, a request has been signed with a token, generated from the consumer key and the shared secret. The provider uses the shared secret to decrypt the token. In case the result is the consumer key, the sender is identified as Moodle respectively a Moodle resource, namely an activity of type external tool.
Once the sender is authenticated, further parameters – such as user, context and role – will be identified. Until this stage, the request is only known as generated by a Moodle activity. The provider will handle the decision upon granting access to any demanded resource. If approved, the user will be logged in automatically, meaning that the provider will create a user session. The provider tool

2 OAuth is a standard for authorization, which has been developed from the Internet Engineering Task Force (IETF). (Hammer-Lahav, 2010)

then can be launched in Moodle – for example, in an iframe or a separate window.

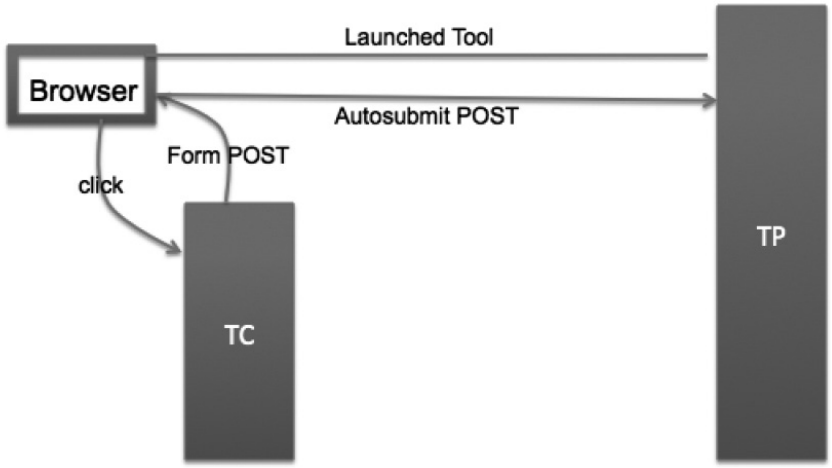

Figure 4. LTI v1.0 (Developers.imsglobal.org, 2015)

Figure displays the process of launching a tool. A Moodle user starts this process by clicking on any link to an activity-instance of the external tool type, representing a connection between Moodle and a protected resource at the provider-side. In this example, the tool consumer TC prepares the launch parameters, signs them via OAuth and then sends a message back to the browser from where it was originally posted. From there it is automatically – this feature is likely to be developed in JavaScript – forwarded to the provider TP. The provider verifies the consumer via OAuth, and in the case of success, it checks further submitted parameters. If access is approved, the external resource can be launched in Moodle.

The second feature for returning outcomes to the consumer is part of LTI since version v1.1. Its purpose is enabling learning platforms to receive assessment information like scores and comments from the external tools. Moodle stores this information in the students' grade books.

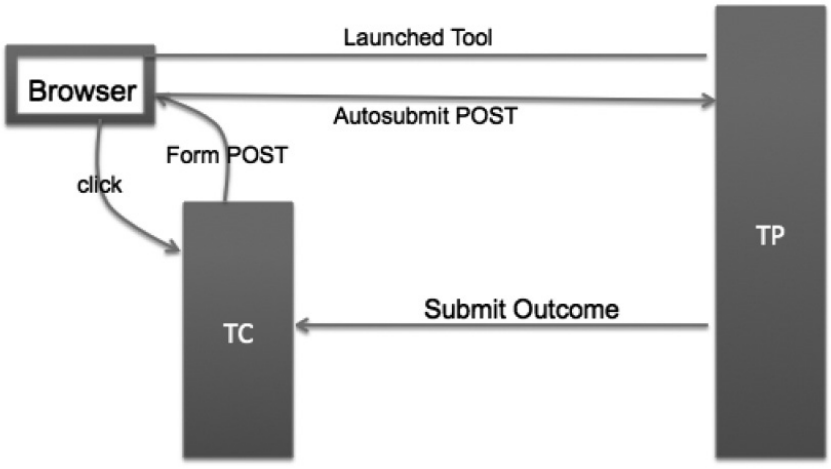

Figure 5. LTI v1.1 (Developers.imsglobal.org, 2015)

The message containing the information for the consumer is completely asynchronous with the tool launch.
Any involved groups – respectively institutions – benefit from LTI in different ways: developers of external tools do not need to have a deeper understanding of the providing platform itself; they might handle it as a black box. Furthermore, developers may choose their preferred language and IDE for the development process. Probably the most important advantage is that a single user interface is suitable for any consumer. Administration of the learning platform, usually a learning management system, profits from LTI as well. It is no longer required to install and test different integrations for each tool-provider. Besides, security and performance of the LMS are not affected, because the connected tools are running in separate environments. Furthermore, updates of the LMS are less risky, as long as the underlying LTI plug-in is not corrupted by the update. Another helpful feature consists of the possibility to authorize teachers so that they also can add LTI connections.

The recent Moodle-version, v2.8, supports LTI-version v2.0, which is the latest LTI-version at that time. Modification of this LTI support will not be necessary until we start to work with competences. The activity *external tool*, which implements the connection between the consumer Moodle and the LTI-tool-provider offers two features, which are essential for our project:

- Authentication via OAuth v1.0a
- Receiving outcomes from WebAssign and entering them into the Moodle grade book

On the provider-side, there is a decisively higher effort necessary, because WebAssign does not support LTI yet. First of all, a requirements' specification is needed, meaning that important decisions about the capability range of the Moodle-WebAssign-integration have to be made.
A typical course at the FernUni is divided into four to seven units with each unit being accompanied by an exercise booklet. These booklets serve as containers for assignments. Since this structure was part of the requirements for the development of WebAssign at that time, it is perfectly integrated. This way to organize and handle assignments limits the flexibility of WebAssign, because it allows not for an asynchronous learning process, which can have its own merits. We have to decide, concerning our prototype, what exactly has to be integrated into Moodle: the assignments, the booklets, or both?
The core feature of the connection is to launch a WebAssign-resource from within a Moodle course. Up to now it is not entirely clear, which types of resources and which workflows shall be opened for Moodle, but we are planning the following scenarios:

- Students working on their assignments
- Teachers creating and editing assignments
- Teachers using the correction workflow

Since students should not realize WebAssign as a separate software or platform, the design of the first here listed workflow is essential.
Some assignment types require manual marking and commenting. This is especially the case for assignments which are handed in as pdf files. WebAssign offers a capable workflow to manage the

process of marked assignments including features like automatic distribution of assignments between teachers and teaching assistants. The distribution modes can be individually configured, which would be an advantageous feature in Moodle, making the usability of external tools even more desirable.
WebAssign offers an interface, which enables teachers to employ additional tools for auto-correcting assignments. Teachers of the department for computer science at the FernUni Hagen used this interface to integrate their own modules for analyzing program code written in Pascal, Java or C++. These additional tools will probably not affect the development of connections between Moodle and WebAssign directly, but they should be kept in mind for further improvements.

Last but not least teachers and students benefit from LTI, because it minimizes the necessary efforts when using of external applications. The choice of tools is only limited by institutions, and this encourages the creation and development of further applicable e-learning tools. This process nourishes an environment for improving the quality of modern education.

We are currently working on the requirements specification of our prototype. To identify the needs of users, we are leading interviews with teachers, teaching assistants and students. As mentioned above, a list of upcoming decisions concerning the range of WebAssign's LTI-support is shown; furthermore some technical aspects are described.
To gain technical expertise with LTI, we first analysed Moodle and its possibilities for integrating external tools and so we experimented with the plug-ins described in section 3 to create a sample connection between two separate Moodles. After that we developed an LTI-provider. As soon as the requirements' specification for the Moodle and WebAssign-integration is complete, we will start designing and implementing our prototype.

5. Conclusions, expected outcome, and future work

Several key issues of our research goals have been outlined along the state of the art in this paper and a first technical milestone of our project has been introduced which is the development of a competence-based course authoring model, and a concept for integrating external e-learning tools into Moodle via LTI.
Later, this concept will be extended to support competence-based learning. As this is not covered by LTI, a solution to exchange competence-specific information will be researched. For this reason we will use platform independent specifications from the *Personal Competence Manager* (PCM) which are in particular the *IMS Learning Design* (LD) to describe the learning scenarios and the *IMS Question & Test Interoperability* (QTI) for assignments, as well as the competence specification to extend both with the features of competence-based learning.
To gain the necessary technical expertise, experience and data for this research project, an LTI-connection prototype will be designed and implemented from scratch, implying the extension of the tool provider for LTI-support. Working with LTI-ready tools is not sufficient in this scenario, because later the connection must be extended for the use of competences, making a deeper knowledge inevitable. The prototype will connect Moodle and WebAssign; latter was the tool of choice, because its Moodle-integration is demanded at the FernUni.
Once the prototype is created, the next agenda item can be tackled: extending the prototype

for the use of competences. Most likely not just the consumer- and provider-protocol have to be modified, but also the connection itself. As mentioned in section 3, FernUni is cooperating with an external institute, and planning to merge competence-based learning with its concept. At this stage of the project, the scheduled course authoring-tool is becoming significant, because it is part of this cooperation. Ideally, this approach will have the potential to be generalized or be treated as kind of best practice in the future.

This paper reflects the state of our research at the time of the *IX International GUIDE Conference in Buenos Aires*. The subsequent publications (Then et. al., 2016a and 2016b) written by the same team of authors than this paper present the latest progress on this issue.

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Sintesi

Il mondo del lavoro nell'era delle nuove tecnologie ha una spiccata natura dinamica per cui i compiti e le attività che i lavoratori devono essere in grado di svolgere e gestire cambiano rapidamente in conseguenza soprattutto dell'adozione di tecnologie sempre più all'avanguardia. La richiesta di aggiornamento professionale e formazione continua è dunque elevata e crescente, ma non sempre tale necessità corrisponde ad una risposta efficace e competente da parte delle istituzioni educative e di formazione. Il Competence-based learning (CBL) costituisce uno strumento per introdurre percorsi di apprendimento informale e formale nella vita di tutti i giorni, durante lo svolgimento delle proprie mansioni lavorative ma anche nel tempo libero. L'articolo analizza le principali caratteristiche del CBL – in particolare il tema della creazione dei contenuti per i corsi competence-based e delle relative valutazioni – con l'obiettivo di ottimizzare e garantire l'interoperabilità tra le infrastrutture tecnologiche esistenti, in soluzioni di e-learning ibride che includano anche l'uso dei software non di ultima generazione. In questo scenario, il punto focale consiste nel raggiungere l'interoperabilità dei software con le infrastrutture già esistenti nonché degli strumenti informatici a disposizione degli utenti con le tecnologie più innovative disponibili sul mercato, garantendo al contempo una facile fruizione per i nuovi utenti e utilizzatori. Viene a tal fine presentato un software di supporto per le attività di authoring e assignment per un corso competence-based, capace di armonizzare e mettere in comunicazione il sistema Moodle con le infrastrutture preesistenti, incorporando gli strumenti già presenti nel sistema attraverso LTI.