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Jampots: a Mashup System towards an E-Learning Ecosystem

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***Abstract*—Although E-Learning has grown into a revolutionary way of learning and is currently widely accepted, it still faces many problems, especially in its implementations. The research community has believed that an E-Learning ecosystem is the next generation E-Learning. Nowadays, the current trend of Web 2.0 has a strong impact on E-Learning. In this paper, mashups are used to build an E-Learning ecosystem. A mashup approach to an E-Learning ecosystem enhances the flourish and sustainability of E-Learning in a productive and cost-effective way. This paper describes the concepts of vertical stack, users and operations in a mashup E-Learning ecosystem. A prototype system, named Jampots, has been built. Jampots has features such as openness, reusability, lightweight structure, end user-orientation and self-regulation.**

Keywords-Web2.0; mashup; E-Learning; E-Learning ecosystem

1 INTRODUCTION

E-Learning is the acquisition and use of knowledge distributed and facilitated by electronic means [1]. It consists of contents delivery in multiple formats, the management of learning experiences, and a networked community of learners, content developers and experts [2]. In recent years it has grown into a widely accepted learning model. However, despite the maturity of E-Learning since its inception, there are still many problems in its implementations. One of the main problems is the challenge of integrating these systems with contents and with other business systems [3]. To solve these problems, the research community has believed that an E-Learning ecosystem is the next generation E-Learning [4] [5].

Recently, Web 2.0 is attracting the attention of IT professionals, businesses and Web users. If the first generation Web has revolutionized the way of navigating relatively static Web sites and accessing contents on a print-based publication mode, Web 2.0 is transforming the Web into an environment that provides richer user experiences by allowing the combination of disparate information in a variety of data formats, the facilitation of interaction between multiple parties, and the collaboration and sharing of information [6] [7]. The impact of Web 2.0 on E-Learning can be summarized as one term: *E-Learning 2.0*. It offers new methodologies and technologies to effectively work in an online community of practice, articulated and promoted by users [8].

Mashup [9] is a hallmark of Web 2.0. A mashup no longer owns its own information and services. Instead, it consists of multiple resources from different providers which can be "mixed" by users into new and more powerful ones. Mashups and E-Learning ecosystems share many principles, such as principles of user-centric, lightweight composition, shared values, collective intelligence, social networking and collaboration of communities.

The research on the E-Learning ecosystem is still in its initial stage. The main contribution of the paper is to build an E-Learning ecosystem using a mashup approach to enhance the flourish and sustainability of E-Learning. A mashup approach allows for greater usability, flexibility and individualization in the implementations of an E-Learning ecosystem.

This paper is organized as follows. Section 2 describes the background. Section 3 presents a mashup E-Learning ecosystem, including its vertical stack, users and operations. Section 4 demonstrates a prototype system of the mashup E-Learning ecosystem, named Jampots. Section 5 evaluates Jampots in terms of openness, reusability, lightweight structure, end user-orientation and self-regulation. Section 6 is the conclusion and future work.

2 BACKGROUND

2.1 Mashups

The term mashup was originally coined in the music domain, referring to artists remixing two or more recordings into a new entity. In the Web context, a mashup is a novel Web page or Web site that combines information and/or services from multiple sources to serve specific and situational demands with end users playing a central role. Making use of collective intelligence, a mashup glues the information and services scattered on the Web together. Through syndication, assembly and orchestration, independent information and services are combined into a new and more powerful entity. Then the new one can be consumed in a new round of disassembly, restructuring, orchestration, sharing and collaboration to create new values.

Mashups can be grouped into seven categories: mapping, search, mobile, messaging, sports, shopping, and movies [10]. ProgrammableWeb.com, one of the most popular mashup directories and marketplaces, lists 3943 mashups on May 6, 2009, with an average of 3.0 new mashups per day.

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Figure 1 shows the distribution of mashups of the ProgrammableWeb.com: about 36% are mapping mashups, and 22% are multimedia mashups (photo, video and music). Most of the current mashups are for non-education use, but the demand and values of mashups in the E-Learning domain have emerged.

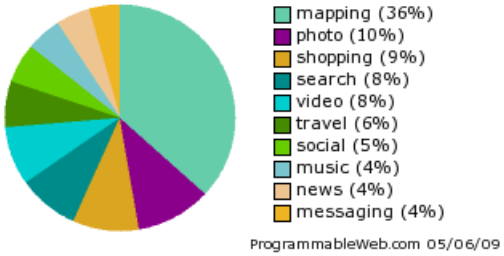

Figure 1. Distribution of mashups statistics from ProgrammableWeb.com

2.2 E-Learning ecosystems

According to the Encyclopedia Britannica, a natural ecosystem is the complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space. Furthermore, it has characteristics such as equilibration, closure, stability, persistence, fluxes, permitted dynamics and so on [11]. An ecosystem facilitates the circulation of materials and the flow of energy, with a strong self-organizing and self-regulation.

An E-Learning ecosystem transposes the concepts to the E-Learning domain, reproducing the desirable mechanisms of a natural ecosystem. Accordingly, an E-Learning ecosystem is the learning community, together with the enterprise, united by a Learning Management System (LMS) [4]. It pays more attention to issues of integrating learning with various contents, services and business processes to support the flourish and sustainability of E-Learning. In the E-Learning ecosystem, symbiotic relationship is broadly shared between practitioners, who benefit much from interacting with learning utilities and collaborating with one another.

3 A MASHUP E-LEARNING ECOSYSTEM

3.1 The vertical stack of a mashup E-Learning ecosystem

A mashup E-Learning ecosystem is a social network model centered around end users. Static information and services are flowed and merged within the ecosystem to create new values. Its vertical stack is divided into four levels, as shown in Figure 2. The relationships, between each level, as well as between the elements within each level, from low to high, constitute the biological chain of a mashup E-Learning ecosystem.

The first level of a mashup E-Learning ecosystem is composed of E-Learning contents, the content processing pipeline and E-Learning syndication contents. *E-Learning contents* comprise E-Learning information and E-Learning services, which are similar to the abiotic constituents of a nature ecosystem. They are mostly exposed in a standard format. The *content processing pipeline* aims to help users syndicate one or more standard content feeds by a set of interconnecting operators and exposes standard feeds as E-Learning syndication content. *E-Learning syndication contents* are customized and complex E-Learning contents, which are closer to users' demands.

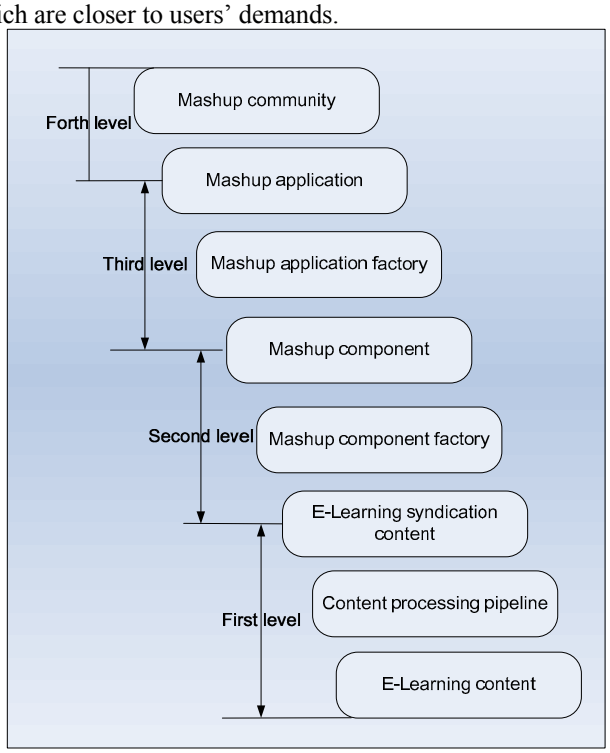

Figure 2. The vertical stack of a mashup E-Learning ecosystem

The second level is composed of E-Learning syndication contents, the mashup component factory, and mashup components. E-Learning syndication contents are the core materials of mashup components. The *mashup component factory* helps users encapsulate E-Learning syndication contents with a user interface (UI) and export as mashup components. *Mashup components* are usually described in the standard XML format. They can trigger predefined behaviors, which can be captured and acted by other mashup components accordingly.

The third level is composed of mashup components, the mashup application factory and mashup applications. Mashup components are not only the exports of the second level but also the materials of the third level. The *mashup application factory* lets users drag and drop mashup components onto the design surface, and interactively configure them by the components' behaviors to orchestrate a mashup application. A *mashup application* is not a simple pile of mashup components, but is the process choreography in accordance with the application logic.

The fourth level of a mashup E-Learning ecosystem, which lies at the top-level of the vertical stack, is composed of mashup applications and the mashup community. In the *mashup community*, individual users form groups spontaneously. Individuals or groups interact and collaborate with one another synchronously and asynchronously. Mashup applications are recreated and consumed by users

through a certain mechanism of the mashup community, so as to bring acquired knowledge to users.

E-Learning contents are the raw materials of a mashup E-Learning ecosystem. *Mashup species*, including E-Learning syndication contents, mashup components and mashup applications, are the consumables of different levels in a mashup E-Learning ecosystem. Mashup species, like living species, evolve or become extinct following the rules of community selection. New, more evolved, innovative mashup species continuously appear, often originated by the combination of simpler species and decree the obsolescence of the other less adapted mashup species which are extinct or close to extinction because of little or no demand [4].

3.2 The users of a mashup E-Learning ecosystem

Users of the traditional E-Learning systems include students, teachers, experts, and so on. Influenced by Web 2.0, especially the idea of collective intelligence, the users of a mashup E-Learning ecosystem are divided into knowledge providers, knowledge discoverers and knowledge consumers, forming the producers of E-Learning contents, the producers of mashup species and consumers in turn.

Knowledge providers include experts, teachers, and students who have strong hands-on abilities and innovations. According to their own knowledge and experiences, they publish E-Learning contents which are mostly exposed in standard formats. Knowledge providers are the knowledge source of the whole E-Learning ecosystem.

Knowledge discoverers can be experts and teachers, but students with self-learning ability tend to become the main members of the role. They have strong requirements and desire towards knowledge acquisition. As opposed to passively accepting knowledge, they prefer taking the initiative to search for knowledge and integrate different knowledge in order to facilitate their studies and researches.

Knowledge discoverers are the producers of mashup species. They syndicate E-Learning contents as E-Learning syndication contents, assemble them into mashup components, and orchestrate interrelated mashup components as mashup applications to strengthen the links among knowledge sources and improve the efficiency of learning. They produce various mashup species and facilitate their own learning at the same time.

Knowledge consumers have intense desire for knowledge, but may not have the capability of creating or discovering knowledge. They utilize mashup species to expand knowledge and benefit from them. They access to mashup species, and provide feedbacks and requirements to knowledge discoverers in order to promote the improvement and re-creation of mashup species.

As is shown in Figure 3, a knowledge consumer can be changed into a knowledge discoverer, or even a knowledge provider through learning. While knowledge providers and knowledge discoverers are relative in some area, in other areas they may also be knowledge consumers. These three types of users have dialectical relationships. They depend on each other, learn from each other and may transform into each other. All of them fully participate in the identifying requirements, production and consumption in a mashup E-Learning ecosystem, and customize situational E-Learning contents and mashup species according to the individual demands. E-Learning contents and mashup species are recycled and improved by the communications, recommendations and feedbacks among them.

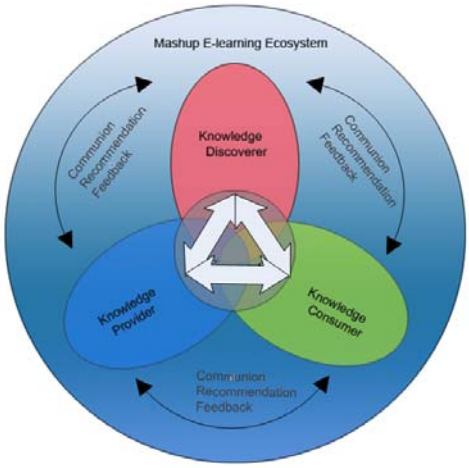

Figure 3. The relationships among the users of a mashup E-Learning ecosystem

3.3 The operations of a mashup E-Learning ecosystem

The circulation of materials and the flow of energy within the ecosystem are two important characteristics of a nature ecosystem. Similarly, as the materials and energy of a mashup E-Learning ecosystem, E-Learning contents and mashup species are also streaming and cycling by some operations.

There are mainly six operations in a mashup E-Learning ecosystem: publish, syndicate, assemble, orchestrate, consume and cooperate.

Publish

Knowledge providers publish E-Learning contents for further use. Also, mashup species are published and registered into the related catalogues by knowledge discoverers.

Syndicate

In the content processing pipeline, E-Learning contents from different sources are combined by filtering, transformation, extraction and enriching. Then the complex content is exposed in a standard data format as E-Learning syndication content.

Assemble

In the mashup component factory, one or more E-Learning syndication contents are assembled into a mashup component with a UI.

Orchestrate

In the mashup application factory, one or more mashup components are orchestrated as a mashup application to implement a complex function. The orchestration model has several distinct styles, such as flow-based style, event-based style and layout-based style [12].

Consume

Knowledge consumers quickly and easily discover and use appropriate mashup species to study, re-create them and obtain knowledge through the consumption mechanisms of a mashup E-Learning ecosystem.

Cooperate

Knowledge providers, knowledge discoverers and knowledge consumers jointly build, maintain and update E-Learning contents and mashup species in a mashup E-Learning ecosystem. The collaboration is built by the community mechanisms, including communications, recommendations and feedbacks. The mashup E-Learning ecosystem is developed and evolved by collective intelligence and the collaboration of the community.

4 A PROTOTYPE SYSTEM: JAMPOTS

4.1 Design objectives of Jampots

Jampots is a mashup E-Learning ecosystem which provides a platform for cooperatively designing, deploying, sharing, managing and recreating E-Learning contents and mashup species for end users. It is hosted on a PHP server, whereas Jampots pages run in a standard Web browser and don't need any plug-ins.

Design objectives of Jampots are as follows:

1. Provide standard encapsulation and unified interfaces of E-Learning contents

In the traditional E-Learning systems, it is difficult to reuse and integrate information and functions because of the differences in system structures or development languages. A mashup E-Learning ecosystem runs on the basis of E-Learning contents which need to be reused and integrated easily. Along with the maturity of Web services, especially the popularization of XML, ATOM, RSS, SOAP, JSON and other standard data formats, standard encapsulations and unified interfaces of E-Learning contents have become a reality. In Jampots, RESTful Web services are used to provide unified descriptions and interfaces for E-Learning contents, supplying convenience for users.

2. Build the production environment of a mashup E-Learning ecosystem

Even if E-Learning contents have been exposed with unified data formats and interfaces, problems such as syndicating E-Learning contents, assembling E-Learning syndication contents and orchestrating mashup components have to be solved. To speed the overall mashup development process and enable even inexperienced end users to construct their own mashup species, following tools are provided in Jampots:

Content processing pipeline

The content processing pipeline is a visual editor to syndicate and structure content feeds. It combines various data formats of E-Learning contents through filtering, transformation and extraction, and the outputs are exposed in a certain data format as E-Learning syndication contents. The content processing pipeline is named *Content Pipe* in Jampots.

Mashup component factory

In the mashup component factory, E-Learning syndication contents are assembled into a small application model - a mashup component. In Jampots, the mashup component, named *ELwidget*, is described by a section of standard XML. The mashup component factory is named *ELwidget Engine*, in which the standard XML descriptions are parsed to generate ELwidgets.

Mashup application factory

In the mashup application factory, multiple ELwidgets are orchestrated to a mashup application through event-based approach. In Jampots, the mashup application factory is named *Mashup Pots*.

3. Provide the community mechanisms of a mashup E-Learning ecosystem

After mashup species are produced, proper mechanisms are needed among consumers and mashup species. Traditional portal-based browsing is not suitable for E-Learning users [13]. Jampots provides is a wiki-based community, in which users rank, share and discuss mashup species to facilitate the organizing and the cooperative management of mashup species. Based on the wiki-based community, Jampots supports the community mechanisms to realize the cooperation between practitioners.

4.2 Architecture of Jampots

Architecturally, Jampots is composed of four layers: E-Learning content layer, E-Learning syndication content layer, mashup component layer and mashup application layer, which is represented in Figure 4.

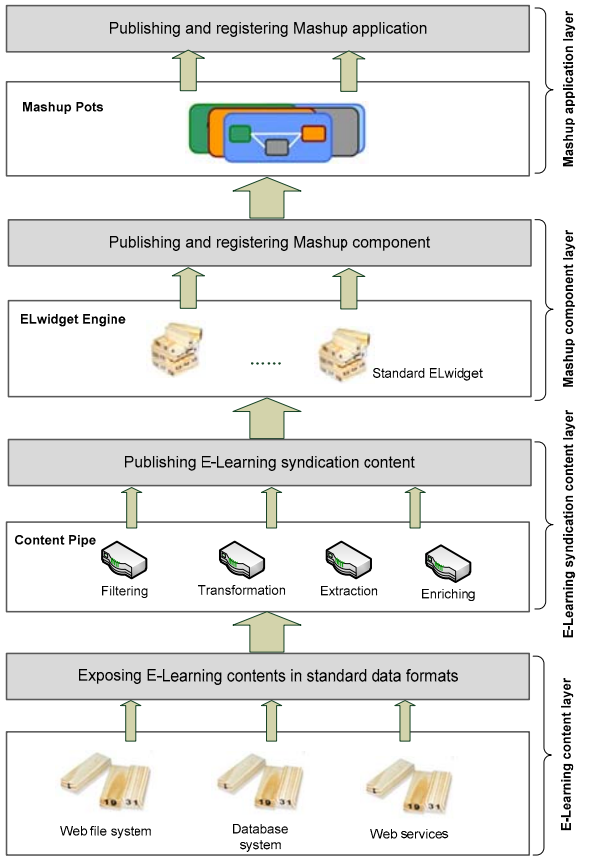

Figure 4. The system architecture of Jampots

E-Learning content layer

The E-Learning content layer is composed of Web file systems, database systems, Web Services and so on. Except for content store and maintenance, this layer also exposes the interfaces and APIs of E-Learning contents on the manner of RESTful Web service. The layer is the material layer of Jampots, and supply raw materials for higher layers.

E-Learning syndication content layer

The E-Learning syndication content layer reprocesses E-Learning contents exposed by the E-Learning content layer. The core component of this layer is Content Pipe, by which E-Learning contents from different data sources are combined through filtering, transformation, extraction and enriching, and then released in a certain standard data format.

Mashup component layer

E-Learning syndication contents are assembled into ELwidgets in the mashup component layer, utilizing interfaces and APIs exposed by the E-Learning syndication content layer. ELwidgets are registered into the mashup component catalogue to be easily discovered and used by users. In order to facilitate the production and use of ELwidgets, Jampots standardizes the design of ELwidgets, using unified XML descriptions to describe the composition, parameters and contents of ELwidgets. ELwidgets expose *CRUD* (create, read, update and delete) interfaces, and have features such as visual drag-and-drop operations. ELwidget Engine is the core component of the layer. In the ELwidget Engine, ELwidgets are parsed and immediately visible.

Mashup application layer

The mashup application layer allows easy and simple organization, search, and integration of ELwidgets. Mashup Pots is the core component of the layer. In this layer ELwidgets are orchestrated into mashup applications. To facilitate end-user orchestrations, the orchestration model should be as simple as possible. Jampots recommends event-based approach, because mashup components are strongly event-based [17]. After the release of a mashup application, it is published and registered into the mashup application catalogue. The mashup application layer conducts community-based management and evolution. From the consumer's point of view, the community-based communications, recommendations and feedbacks enable consumers to find the necessary mashup applications easily and quickly. From the producers' point of view, the community-based communications, recommendations and feedbacks enables producers to adjust and improve their mashup applications to meet consumers' demands.

The layered architecture presented in this section is an implementation of the vertical stack presented in section 3.2. The E-Learning content layer and E-Learning syndication content layer are related to the first level of the vertical stack in Figure 2, and the mashup component layer is related to the second level, while the mashup application layer is related to the third and fourth level.

4.3 The network model of Jampots

Jampots is an end user-centric Rich Internet Application (RIA). Its network model is composed of browser layer, agency layer and content server layer. Interactions between different layers are carried out through JavaScript, Ajax and RESTful Web services. The network model of Jampots is shown as Figure 5.

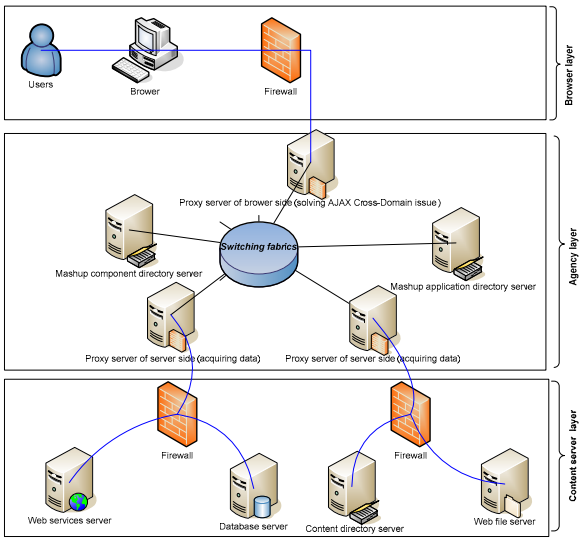

Figure 5. The network model of Jampots

Browser layer

In Jampots, users are often both producers and consumers. As a result, a unified user interface is needed for constructing and consuming mashup species just by simple operations such as point-and-click and drag-and-drop, and the complex processes behind these simple operations are mainly implemented in JavaScript and Ajax. They transmit the users' requests to related servers, interact with these servers, and then reply the corresponding responses to users.

The browser layer is the first encapsulation and barrier of Jampots. Due to security concern, Ajax cross-domain access is currently restricted in all browsers.

Agency layer

To solve the security issue of Ajax cross-domain access mentioned in the previous section, the agency layer contains some special proxy servers to solve the Ajax requests from the browser. After parsing and encapsulation by a proxy server, the request is transmitted to the target server. Then the request is handled by the target server, and the corresponding response is replied to the proxy server. At last the response is sent to the browser by the proxy server.

Directory services are also provided by the agency layer. The mashup component directory server supports the register of mashup components, while the mashup application directory server supports the register of mashup applications. Those proxy servers and directory servers communicate through the high-speed switching fabrics.

Content server layer

In Jampots, E-Learning contents are gathered from scattered resources which are released by Web file systems, database systems or Web Services. Wherever are they from, they are based on the servers, which are usually heterogeneous and distributed. Generally, accessing permission on different content servers varies.

5 EVALUATIONS

Jampots is a situational and end user-centric mashup E-Learning ecosystem based on RESTful Web services. It emphasizes the sharing of E-Learning contents, flexible combinations of mashup species, and the attention and participations of end users.

Main features of Jampots are as follows:

Openness

As an E-Learning ecosystem for the benefit of end users, Jampots has features of the openness of information, uniform service interfaces and low-threshold technologies, which are all people-participating and open to communities by interconnecting isolated E-Learning systems.

Reusability

Mashup applications are orchestrated by mashup components, which can be then separated from the mashup applications. In order to develop a new application, it is not necessary to do so from scratch. It is possible to combine these existent components so that the components are constantly reused. Similarly, mashup components, E-Learning syndication contents and E-Learning contents are also easily reused.

Lightweight structure

Since Jampots is based on Ajax, RESTful Web services and standard data formats, it is convenient for development. From the point of system architecture, Jampots is a typical rich internet application. Most of its operations and functions run at the client (the browser), and in the server complex applications can be carried out by a certain dynamic script such as PHP.

End user-orientation

The tools of Jampots help moving mashup development from manual and time-consuming scripting to a set of easy-to-use and extensible parameterized patterns. It enables end users who are not good at programming to establish new situational applications by some simple actions such as point-and-click and drag-and-drop.

Self-regulation

Jampots is self-regulated based on factors such as learning styles, learning strategies, learning preferences, learning environment and cognitive levels. The right of control is available for end users interactions, and the self-regulation are revealed in Jampots by sharing, communications, recommendations and feedbacks among practitioners of the E-Learning ecosystem.

6 CONCLUSION AND FUTURE WORK

An E-Learning ecosystem has attracted the research community as the next generation E-Learning. Web 2.0 has greatly changed people's life, including the learning habits and learning styles. In this paper a mashup E-Learning ecosystem is presented, especially its vertical stack, users and operations. A mashup E-Learning ecosystem brings great benefits to E-Learning, such as usability, agility, flexibility and individualization. Furthermore, a mashup approach to an E-Learning ecosystem is quite productive and cost-effective. A prototype system of the mashup E-Learning ecosystem Jampots has been built. Jampots has the features such as openness, reusability, lightweight structure, end user-orientation and self-regulation.

As future work, Cloud computing will be introduced to a mashup E-Learning ecosystem. The technology of Cloud computing allows for reliability, stage support, security, and scalability. These features will promote the sustainability of a mashup E-Learning ecosystem.

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