Why Web 2.0 is Good for Learning and for Research: Principles and Prototypes

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ABSTRACT

The term "Web 2.0" is used to describe applications that distinguish themselves from previous generations of software by a number of principles. Existing work shows that Web 2.0 applications can be successfully exploited for technology-enhance learning. However, in-depth analyses of the relationship between Web 2.0 *technology* on the one hand and *teaching and learning* on the other hand are still rare. In this article, we will analyze the technological principles of the Web 2.0 and describe their pedagogical implications on learning. We will furthermore show that Web 2.0 is not only well suited for learning but also for *research* on learning: the wealth of services that is available and their openness regarding API and data allow to assemble prototypes of technology-supported learning applications in amazingly small amount of time. These prototypes can be used to evaluate research hypotheses quickly. We will present two example prototypes and discuss the lessons we learned from building and using these prototypes.

Categories and Subject Descriptors

K.3.1 [**Computing Milieux**]: Computers and Education-Computer Uses in Education; H.4.3 [**Information Systems**]: Information Systems ApplicationsCommunications Applications

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Keywords

Education, Research, Web 2.0

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1. WEB 2.0 AND LEARNING

1.1 Introduction

Today, the term Web 2.0 is used to describe applications that distinguish themselves from previous generations of software by a number of principles. These new, Web 2.0, applications take full advantage of the network nature of the Web: they encourage participation, are inherently social and open. Whereas Web 2.0 is not characterized by a new step of technology as is the Semantic Web [10], in the last years the Web changed from a medium to a platform, from a read-web to a read-write-web, thereby fulfilling Berners-Lee's original vision of the Web [9].

These principles are in line with modern educational theories such as constructivism and connectionism and thus make Web 2.0 applications very attractive for teachers and learners. Wikis, blogs, and social bookmarking are now commonly used in learning [2]. Recent work at the crossroads of technology-enhanced learning (TEL) and Web research focuses on exploiting Web 2.0 features such as tags for user modeling [16], personalization of mashups [36], and ontologies and authoring [1].

While this research shows convincing examples of using Web 2.0 services for learning, in-depth analyses of the relationship between Web 2.0 *technology* on the one hand and *teaching and learning* on the other hand are still rare. However, the significance to understand the implications of technology is underlined by Noss [28] who asks "[w]hat kinds of pedagogy are appropriate to using [a new] technology and, more fundamentally, how does this technology change the epistemologies of what may or may not be taught in schools". Being able to evaluate the implications of an technology, i. e., "critical media literacy" [17], requires understanding the very basics of this technology.

With respect to education, it is indeed the case that technical features often impose a specific pedagogical approach. For instance, typical learning management systems such as Blackboard[1] present courses as mostly static Web pages, enriched with multiple choice questions. These traditional learning management systems implement what Schulmeister [32] calls "administered learning", which is based on the knowledge-transfer paradigm of behaviorist learning. In con-

[1] `http://www.blackboard.com`

trast, Intelligent Tutoring Systems (ITS) are associated with cognitive theories of learning: an ITS usually implements user-adaptive teaching based on a cognitive theory of the mind [23], such as the PACT-tutors building on Anderson's ACT-* theory [4, 5].

Obviously, such a classification is very broad and does not capture the field of TEL in all details (e.g. ACTIVEMATH [25] is a Web-based learning environment based on constructivist paradigms), but the relevant point is that one often observes that technical characteristics lead to specific pedagogical characteristics. Thus, it is important to analyze the technological basics underlying Web 2.0.

1.2 Overview on the Article

The contribution of this paper is as follows:

- First, we will analyze the technological principles of the Web 2.0 and elaborate on their pedagogical implications on learning. The focus on technological principles distinguished our work from prior research in this area, such as [19, 2] that explores the potential of Web 2.0 for education in general or [6] that describes the Web 2.0 principles for an educational audience .

- Secondly, we intend to show that Web 2.0 is not only well suited for learning but also for *research* on learning: the wealth of services that is available and their openness regarding programming interfaces and data allow to assemble prototypes of technology-supported learning applications in amazingly small amount of time. These prototypes can be used to evaluate research hypotheses quickly.

The in-depth analysis is subject of Section 2. In Section 3, we will elaborate on what we mean by rapid prototyping of learning applications. We will present two examples that we realized: micro-blogging for language learning 3.1 and social bookmarking for authoring learning object annotations 3.2. These two projects allowed us to learn practical lessons about using Web 2.0 services for prototyping, which we will discuss in Section 4. We will start by briefly introducing one of today's prevalent learning theory, constructivism, which will provide a context for the subsequent analysis.

1.3 Parenthesis: Constructivism

Constructivism is based on the premise that knowledge cannot be transmitted but has to be constructed by the individual. Therefore, learning is an active process of integrating information with pre-existing knowledge.

Cognitively oriented constructivist theories such as discovery learning [13] and microworlds [31] emphasize exploration and discovery. Socially oriented constructivist theories, such as social constructivism [41] and cognitive apprenticeships [12] stress the collaborative efforts of groups of learners as sources of learning.

In constructivism, the control over the learning process shifts from the teacher to student, with the learner playing an active role in the learning process. Learning takes place in context and in collaboration and provides opportunities to solve realistic and meaningful problems. In contrast, the teachers focus mainly on preparatory activities and provide support in case assistance is needed. Consequently, the teacher is an initiator of and an adviser in the learning process.

The last years have seen an increasing research in and appliance of constructivist approaches. Pure constructivist approaches, however, are not unchallenged: instructions and drill still need to play a part in the classroom [24]. Hence, the moderate constructivist theory has developed as a pragmatic approach which integrates instructions into a theory that has a clear constructivist tendency.

2. ANALYZING WEB 2.0 PRINCIPLES FROM A LEARNING PERSPECTIVE

The term "Web 2.0" runs danger of becoming a buzzword as empty as "e-learning": some years ago, every learning software that used the Internet in some way was coined as "e-learning software", regardless of whether it was innovative or helpful for learning. Today, Web 2.0 faces the same fate: every Web-site with a fancy interface is sold as Web 2.0.

However, careful analysis shows that Web 2.0 can be used to describe a new set of software applications that distinguish itself from previous applications by a number of principles. While in the beginning of the Internet, software was modeled after the practices prevalent at that time, slowly a new kind of applications emerged. The defining principles of these applications were first captured by O'Reilly [30]. Anderson [6] used a slightly different categorization of what he calls the "big ideas" of Web 2.0 and gives examples of current usages of Web 2.0 services for learning and digital libraries.

None of the principles is a new technology or development for itself. As the inventor of the Web, Tim Berners-Lee, points out, Web 2.0 works on the same standards as Web 1.0 [6], and his original vision of the Web was the one of a "read-write-Web", where everyone could add and edit Web pages [9]. However, taken together the "big ideas of Web 2.0" have reached a critical mass that transforms the way of publishing and information exchange so distinctively that the term "Web 2.0" is warranted.

In the following, we will analyze Web 2.0 principles (based on [30, 6]) and analyze each principle with respect to the implication on technology-enhanced learning. This will allow us to make general statements about the implications of Web 2.0 on pedagogy based on the inherent technical features of Web 2.0.

2.1 Individual Creativity

Web 2.0 enables and facilitates the active participation of each user. Web 2.0 applications and services allow publishing and storing of textual information, by individuals (blogs) and collectively (wikis), of audio recordings (podcasts), of video material (vidcasts), of pictures, etc. Authoring of this user generated content is greatly facilitated by providing easy to use desktop-like interfaces. While some time ago, Web applications were easily distinguishable from their desktop counterparts due to their design and point-click-wait interaction, today's Web 2.0 applications are often recognizable as being Web application only at second glance. Due to techniques such as Ajax and Flash, responses from the user interface now behave similar to desktop applications (as long as a fast Internet connection is available). Additionally, Web 2.0 services typically put much effort in usability and aim at simplifying the interactions as much as possible by concentrating on the task or service the application provides. Customers often have several similar services

to choose from, and as consequence a service is designed to please in order to attract and keep the customers.

This stimulation of active participation distinguishes Web 2.0 based learning from traditional "Web 1.0" learning, which is exemplified in traditional learning management systems, where users read Web pages and solve exercises but cannot contribute and social interactions are restricted to forums. Together with the social dimension captured by the "harnessing of the power of the crowds", these two principles are the most visible ones and as such the most analyzed and stressed by pedagogical research: Downes stresses the constructivist nature of these principles and contrasts the delivered learning of learning management systems with the learner-centered activities triggered by Web 2.0 applications: "the Web was shifting from being a medium, in which information was transmitted and consumed, into being a platform, in which content was created, shared, remixed, repurposed, and passed along" [19].

However, this raises the question how the learner is supported in his usage of these tools and resources. Studies show that students rarely develop explicit learning strategies on their own. According to [35], disorientation and cognitive overload are the principal obstacles of self-regulated learning in technology-enhanced learning. This and similar studies [29] provide evidence that students must *learn* to self-regulate their learning process since most of them do not posses this skill.

While in traditional Web-based technology-enhanced learning existing research shows how to provide pedagogically supported access to resources and learning supporting tools within a server-based learning environment [38], only little research has investigated on using such techniques for Web 2.0 based learning (e. g., [36] for personalization of mashups in the domain of tourism).

2.2 Harnessing the Power of the Crowd

Web 2.0 services are characterized by the fact that their value increases the more people are using it. A traditional static Web site does not "improve" when visited by large amounts of surfers since it presents its content the same, static way. In contrast, Web 2.0 sites use information provided by the visitors explicitly (user contributions build up the site or part of it) or implicitly (user activities on the site are used for adapting its content or presentation).

The explicit and implicit harnessing of the power of the crowd are best exemplified by Wikipedia and Amazon. In the online encyclopedia Wikipedia, the user explicitly contribute to the encyclopedia by adding and editing articles. In the online shop Amazon, collaborative filtering based on the shopping behavior is used for making suggestions to the customers. Each page describing an article contains suggestions of related products ("Customers who bought this item also bought ...").

What are the implications of the principle of harnessing collective intelligence for education? First of all, in Web 2.0 services potentially large amounts of other users will exists and active contribution is encouraged (see the previous principle). Each user is therefore immediately a member of a community with a low barrier to participate.

Constructivism sees learning as activity that takes place in a social context [41]. Thus generally speaking, these innate properties of Web 2.0 services are beneficial for learning. An obvious example is learning of a foreign language. In Section 3.1 we describe how we used micro-blogging, i. e., SMS-like news exchange between users, for learning English as a second language. The large community of pre-existing users of this service allowed the learners to observe communication of native speakers and to practice by communicating with other users who were no member of the class.

Even in domains other than language learning, the value of communicating is important. For instance, in mathematics learning being able to verbally explain results and problem solving steps is increasingly emphasized. Competency-based learning as, among others, put forward by Niss [27] regards communication of results as similar important as formal proving skills.

On the other hand, having the learners engaged in an unrestricted community can be distracting. During our micro-blogging usage, learners suddenly started to post German and Japanese messages, which in itself is no bad thing but distracted from the goal of practicing English. Additionally, unmoderated contributions can be problematic if offending content is posted. However most Web 2.0 services have built-in quality control mechanisms.

Collective contribution of content can be problematic in case assumptions are made regarding the data provided by the users. The second case study described in this article uses social bookmarking services for easy authoring of learning objects. There, bookmarks are stored on a Web 2.0 service[2] annotated with tags that provide additional information about the bookmarked resources. In the case study, the tags were predefined and carried specific semantics that were exploited by a learning management system to suggest new learning resources. However, such a fixed semantic can be enforced only in closed communities. Otherwise, problems might arise if by chance other users employ the same tags but with a different semantic. While most Web 2.0 services offer a possibility to define closed communities,[3] this of course undermines the benefits of an open community.

Some research was performed on harnessing the collective intelligence for e-learning applications. For instance, [1, 8, 42] investigate the usage of tags for ontology generation and authoring support.

2.3 Diverse Data on an Epic Scale

In Web 2.0, data is often as important as function. Take del.icio.us as an example: its functionality is voluntarily limited to the basic function of bookmarking with tags, however, the value of del.icio.us emerges from the massive amount of annotated resources. Thus Web 2.0 services employ different measures for increasing user contributions and participations, for instance by building trust (e. g., offering users to leave with an export of their data), by explicit licenses (often open licenses such as Creative Commons), and paradoxically, by making content accessible through RSS syndication and APIs. Behind the user-provided data of Web 2.0 lies the Semantic Web [10] with its vision to make the data currently hidden in databases available for usage by machines.

As a result, Web 2.0 enables access to data at an unprecedented scale, such as pictures (e. g., Flickr) [4]), bookmarks, mapping data (e. g., Google Maps), but also indexed data,

[2] `http://del.icio.us`

[3] See, e. g., `http://www.corank.com/` as an community-based alternative to del.icio.us.

[4] `http://www.flickr.com`

such as the Google search index. Some of this data was available in the Web 1.0, however not as well-annotated and centralized.

This content can be exploited for learning in various ways. First, learners (and teachers) can use existing resources during their learning process as information sources (e. g., Wikipedia articles as starting points to learn about concepts). Furthermore, active knowledge construction is supported: learners can use the data as building blocks for creating new content (mixing or mash-up of content).

Most of this content is not designed for instruction, but is real world data, uttered by real people in real contexts. As such, it is better suited for constructivist approaches than for Instructional Design with its emphasis on very specifically designed content elements that try to elicit specific instructional outcomes [26]. This is not to say that constructivism does not value carefully authored content. However, the content takes a less prominent role.

The abundance of available data has also advantages for the e-learning researcher. For instance, it is now easier than ever to build tools that exploit the data to enrich the learning experiences. A vocabulary trainer could automatically enrich the words to be learned by retrieving pictures from Flickr or videos from YouTube.

The main problems consist of license problems, plagiarism and disappearing data. Often, remixed content is based on copy-protected material since especially young users are not aware of potential restrictions. Closely related is the problem of plagiarism. While reusing previous work is not a bad thing in itself, pretending to be the original author of a work certainly is, and copy-and-pasting related work without citation is more and more wide-spread [34]. The problem of no longer available data is as old as the Web, but is potentially order of magnitudes larger: whereas previously referenced data consisted of a single document (the link target), now an API change (or the closing of a service) can make the complete data of a Web 2.0 service unavailable. However, such actions will almost certainly face massive opposition from the users, and the fear of loss of users will (hopefully) prevent such actions.

2.4 Architecture of Assembly

Similar to traditional Web services, the Web 2.0 makes data and functionality accessible. Users can access Web 2.0 services by browsing the Web sites but also through APIs. Typically, APIs allow to add, change, and retrieve data. Content is disseminated by RSS/Atom feeds that allows users to pull the data without ever visiting the site itself. Most content created in the Web 2.0 is micro-content: small, self-contained units, such as blog entries, images and other multimedia content well suited for remixing [18]. This micro-content can be combined with other data and services, e. g., tags of Flickr photos can be used to show the location in Google Maps. In difference to traditional Web-services, the Web 2.0 approach is characterized by pragmatic solutions and lightweight formats.

Additionally, existing Web 2.0 services often disseminate their functionality by plug-in modular components, so called widgets [15]. This allows integrating the service on a given Web-site by adding only several lines of code. For instance, the microblogging service used in our second use case can be added in the blogs of the learners very easily.

The potential for education resulting from this mix-up / mash-up culture is twofold. First, individual creativity can take place at a level higher than content: just like new content is created by combining other content, new functionality is created by mash-ups. Secondly, the syndication of functionality by widgets allows extending existing learning environments. This way, additional expression channels can be added at a very low cost. Personal Learning Environments (PLE) takes this concept one step further. A PLE [39] is not a pre-build collection of tools and content but a framework that allows a learner to assemble his own suite of applications and content sources. It is build on Web 2.0 technology and uses Web 2.0 services, such as blogs, wikis and social bookmarking. Various content sources, applications, such as e-portfolios [7], and information from social networks are integrated by the learner with the PLE.

Being able to construct your own learning environment is surely a constructivist notion. But again the problem arises that especially weak learners may not be able to assemble and use such tools efficiently.

Additionally, the "architecture of assembly" and its extensive usage of third-party services might result in technical problems. APIs of a service can change and unlike traditional software there is no prior version to revert to. Additionally, rate limits can raise problems. Often, Web 2.0 services impose rate limits, e. g., by specifying a maximum number of request a client can send per hour. This can interfere with educational applications, for instance if interactions or content created by learners is to be downloaded for off-line analysis (see Section 3.1).

Also, one needs to be aware that using third-party content within an applications can lead to security problems, such as Cross Site Scripting (XSS) attacks [22].

2.5 Independent Access to Data

Ideally, Web 2.0 services reach for a wider range of clients than the PC browser. They allow access from and dissemination of data to devices such as mobile phones, PDAs, game consoles, etc. By offering multiple sources of input, this principle increases potential participation of the user. Additionally, the location-awareness that often comes along with mobile devices makes new applications possible, e. g., location-aware dating, sight-seeing, etc.

In addition to device independence, the data on a Web page itself becomes independent of the intended usage of the server and, as a consequence, resources located at an URL become usable in a number of ways. Rendering the data for presentation in a browser, the standard processing of today, is only one of the multiple potential applications. For instance, micro-formats can be used to annotate part of the data. These are predefined mark-up languages that allow to a annotate data on Web pages and thereby assigning a semantic [21, 11]. This semantic is exploited not by the server but by the client using plug-ins. For instance, contact information on a Web page that is annotated with the `hcard` micro-format can be directly exported to a mail program or address book. It is no longer the server that defines the usage of the Web data, but the client. The browser starts to act a as information broker.

From a pedagogical viewpoint, having additional means for active participation is advantageous. Being able to participate from everywhere using mobile device will lead to less artificial learning situations, which do not take place in front

of the computer but in the context of the real life, a characteristic stressed by constructivist learning. The micro-blogging service described later in this article allows sending blogging-messages from the mobile phone. This way, the learners could participate wherever they were. The additional benefit of location-awareness can give rise to new learning scenarios [33].

For the researcher who is using Web 2.0 services, the additional features offered by multiple devices come for free. There is no extra development and programming effort necessary.

2.6 Leveraging the Long Tail

The Long Tail captures the observation that often demand (for a product, information or service) is characterized by a power law, i. e., a decreasing curve with a small number of highly frequently occurring events and a very large number of events that occur with a low frequency [3, 14]. In the physical world, the limited shelf-space cuts the growth of the tail. However in the digital world, with its virtually unlimited space, no barrier hinders the growth and thus enables reaching critical mass of demand even for niche-products. Web 2.0 sites often especially cater for the Long Tail, for instance by facilitating community building.

For learning, the interest of Web 2.0 services to enable the Long Tail has the effect that on the one hand creation and construction of content but also making content public has become easier than ever. This allows producing, publishing, receiving and giving feedback. Again, this is not restricted to language learning: creating, discussing and subsequently revising the creations are essential parts of learning as seen in constructivism.

In addition, social networking can be used to find peers with similar interest both for school and college students but also for vocational learners. Matchmaking between peers with common interests is also a hot topic in Web 2.0 as exemplified by services that employ user information to find users with similar interest, e. g., based on their browsing behavior.[5]

Similar to previous patterns, this pattern involves connecting between learners and "strangers", which might result in problems. Lately, the social network Myspace was criticized for not taking sufficient measures to protect minors in their network. While such events are not representative, they show that teaching personnel should keep an eye on what the learners are doing, for instance by letting them report (in class or by blog) about their learning progress.

2.7 Perpetual Beta

"Perpetual beta" and the following principle "lightweight models" capture organizational issues related to the software development that only indirectly influence the user. However, they are listed here since they capture parts of what defines the Web 2.0 and they have an effect on the e-learning researcher.

In contrast to traditional software, Web 2.0 applications are no longer released in version-based software packages, one version at a time, but are constantly refined and improved. Changes to services happen gradually, there is no Google 1.2. This is facilitated by the ability of Web applications to track the user's interaction with the service and thereby gathering data about interaction patterns that is nearly impossible to collect for desktop applications.

While constant improvement of a service is not a bad thing, new or changed features may lead to confusion of learners who are using the service and may lead to distract from the task at hand. Changes in functionality and user interfaces require adapting previously written manuals. Sometimes parts of services are stopped completely, as it happened recently with the fee-based Google Video.

This principle does not endorse a pedagogical theory. However, it has an effect on teachers/researchers that use a specific service. One advantage of the perpetual beta is that the developers are usually open to suggestions from adaptors. They often set-up developer discussion boards and use these to receive additional feedback. In our micro-blogging use case, we made the experience that the main developers of the service were strongly open to suggestions and adapted existing APIs and introduced new ones in response.

2.8 Lightweight Models

Software development in Web 2.0 is characterized by its focus on high-level functionality. Today, freely available software has reached a level of maturity that allows to build applications by focusing on high-level functionality. The LAMP stack (Linux, Apache, MySQL, and PHP) and frameworks such as Ruby on Rails and Django[6] enable the creation of Web 2.0 services in a very limited amount of time. The effect of the availability of such high-level functionality is explored in Section 3, where we describe how we used existing services for rapid prototyping of technology-enhanced learning applications.

2.9 Summary

The term "E-Learning 2.0" coined by Downes [19] illustrates the observation that the characteristics of the Web as it manifests itself today, the "Web 2.0", bring forth implications on teaching and learning. Indeed, the above analysis shows that in so far as one can speak of an "innate" pedagogy of a technological artifact, the Web 2.0 is characterized by social learning and active participation, as advocated by constructivism.

In the following section, we will illustrate the potential of the Web 2.0 extends to research itself. It has never been easier to assemble prototypes that help to evaluate the potential of new e-learning applications.

3. WEB 2.0 AS A RESEARCH TOOL

Just like the Web 2.0 has transformed the Web and the way people use the Web, we believe that Web 2.0 has the potential to transform research in technology-enhanced learning. We base this claim on two observations: first, on the wealth and variety of Web 2.0 services that are available today, and second, on the low complexity of exploiting the functionality of the services by APIs, which allows to implement functionality on top of these services.

- The wealth of functionality (mostly) freely available today is unparalleled. To cite but a few examples relevant for learning: e-portfolios[7], navigation analysis[8],

[5] http://www.stumbleupon.com/

[6] http://www.rubyonrails.org/, http://www.djangoproject.com/

[7] http://www.google.com/notebook

[8] http://www.google.com/analytics

conversion of spoken word to text and vice versa[9], collaborative office functionality[10], video editing[11], etc.

- The Web technology has matured to such a degree that complex applications can be assembled in a very short time. Mash-up engines like Yahoo Pipes and Microsoft's Popfly[12] allow a drag&drop construction of applications that integrate functionality from existing services without any programming knowledge. More complex exploitation is achieved by access through open APIs.

We argue that until now the potential that arises from these facts has not been sufficiently stressed: instead of (re)implementing services, the researcher in the area of technology enhanced learning should reuse existing services. The wealth and accessibility of functionality allows to assemble complex prototypes in a small matter of time. These prototypes are usually stable enough for evaluation and validation of research hypotheses. In order to illustrate these claims, in the following, we will describe how we used two existing Web 2.0 service for rapid prototyping

3.1 Micro-Blogging for Language Learning

The research described in this section was performed at the distant university of Shanghai Jiao Tong university whose students to a large percentage consist of vocational learners. The research question investigated was how to increase active participation of the students in oral communication courses for English as a second language. In the traditional Chinese education system, knowledge transmission from the teacher to the learner is valued higher than active participation of the learner in the classroom [43]. Therefore, even adult learners do not feel comfortable practicing in front of fellow learners. Additionally, being vocational learners, the students did often not find the time to practice outside the classroom hours.

Our research therefore focused on the question how to provide practice possibilities that the students could use in their limited time and without fear of loosing their face. We decided to investigate micro-blogging, a type of blogging that enables users to post short messages that are distributed within their community. Users can post messages from their mobile devices, a Web page, and from Instant Messengers. The same channels are used for receiving messages from other users.

Micro-blogging was used in the lecture in the following way: the lecturer created an account at an existing micro-blogging service (Twitter[13]). As a homework, the students of the lecture were prompted to create their own account and to become "friends" with the lecturer as well as with the other students. Since each Twitter user receives the messages of his or her friends, each student who followed the instruction would receive the messages of his/her fellow students. The students were then told to post a least seven micro-blogging messages a week and to read the incoming messages of their fellow students.

During the lecture, our expectations that micro-blogging offers a number of possibilities, services and advantages which differ from the standard classroom interaction were confirmed. In the classroom, when they students have to talk to their foreign teacher in a foreign language, they feel very shy and timid and often find themselves at loss of words. This is partly due to the nervousness caused by the situation; and it is partly due to their limited vocabulary. Using micro-blogging, the students can take their time before responding or commenting and are thus relieved of some of their pressure; and they can also consult a dictionary to find a suitable but unknown word or expression.

From a linguistic point of view, micro-blogging is a communicative approach to the teaching and learning of a foreign language. The students use the foreign language not to fulfill a task, but to communicate about their daily chores, activities, current events, etc—very much the same thing they would do in their native tongue. And in contrast to classroom interaction, Twitter offers the students do so at any time they like.

The aspect of free choice of time is especially suitable for our target group. This group consists of students enrolled at a college offering a combination of evening classes and distance learning courses. The majority of the students has job; and since they are already taking classes in the evening, their busy schedule allows them little time to study and practice. However, most of the students have computer access during their working hours, and so they can visit the micro-blogging website and read the messages sent by the classmates and respond, or simply write a message by themselves whenever they have some minutes of spare time.

The interactional aspect of the micro-blogging site offers a further advantage: probably no student would consider it a "break from work" to practice drill sentences or review a grammar lesson, but visiting the micro-blogging website and communicating with classmates is perceived as "taking a break from work" and relaxing for a few minutes, although the students are actually practicing their language communication skills. In fact, some students noted that micro-blogging had an additional advantageous side effect: the atmosphere between the classmates improved, and meeting on the micro-blogging Web site gave them the impression of meeting on a virtual schoolyard.

Since Twitter is an open community where messages can be read by all users, not only friends, the students were contacted and contacted other users from outside the class; among them native speakers of English. As a consequence, they do not only use micro-blogging among each other but also with native speakers, which will further improve their communication skills concerning "real-use" of English.

The micro-blogging service we used offers the possibility to send direct messages. Then only two parties can view the message. This is particularly helpful when a student has a question which he does not want to ask "in public" (fear of face loss), or to clarify a point, etc. The students can use this service to communicate directly with each other, or to communicate directly with their teacher. On the other hand, the teacher can correct mistakes by sending a direct message to the student who made the mistake without involving other students.

In order to facilitate the teacher's access of the micro-blogging service, we implemented an "offline" application. The application automatically downloaded all the students

[9] http://www.jott.com/, http://www.spokentext.net/
[10] http://docs.google.com/
[11] http://www.jumpcut.com/
[12] http://pipes.yahoo.com/pipes/, http://www.popfly.com/
[13] http://twitter.com.

messages and implements a limited form of automatic grading (the more messages sent, the higher the score). It also allows an easier analysis of the amount and content of the interactions. The application accessed the Twitter service through its open APIs: for each learner, the list of recent messages was requested and the content of each message was downloaded.

How are the Web 2.0 principles previously identified reflected in the micro-blogging project? When planning the project, we expected the following: the stimulation of individual creativity would motivate the students to participate actively at times suitable for them, using several devices, i. e., Web interface, instant messenger and SMS. The power of the crowd and the long tail of interest of Twitter users would allow the students to find native speakers with similar interests. At the same time, being able to see their fellow students messages, would improve the sense of community. From a technical site, the architecture of assembly and the lightweight models would allow to construct the prototype in a limited amount of time.

Most of our expectations were confirmed and will be reported in detail in Section 4. Regarding the technical efforts required to use the Web 2.0 as a research tool, they were indeed low. By building on an existing and open service (Principle "architecture of assembly") we were able to offer the students a environment much more attractive than would have been possible by implementing it from scratch. At the same time, due to the open API, we could access all the data required for investigating our research hypotheses. Thanks to existing Web frameworks ("lightweight models") such as Ruby on Rails, we were able to build the download tool in about a person month, a time that includes getting familiar with the Rails framework.

3.2 Social Bookmarking for Learning Object Annotation

Authoring learning resources is a time consuming and difficult task. In this project, we focused on the question how lecturers with no or little knowledge of the technical details of learning resources and metadata standards can be supported while collecting content for their courses. Firstly, to be accepted by the users, this activity needs to integrate in their usual work-flow, without imposing additional load. Secondly, student research assistants should be able contribute to the collected resources, too. A third constraint was imposed by the organizational factors: any solution needed to be integrated in the learning management system used by the participating organization (the distant university of Shanghai Jiao Tong University, NEC).

Our solution is based on social bookmarking. Not surprisingly, we found that in their daily routine, lecturers search the Web for resources they can use in their lectures and mark them with bookmarks. While standard bookmarks are stored locally and hence only available for a single user and not reusable by other users, social bookmarking allows storing bookmarks on a server, accessible by other users and additionally annotated with user-defined tags. We therefore encouraged the lecturers to use social bookmarking service to store their bookmarks. Additionally, we instructed the lecturers to use a mixture of user-defined and predefined tags (in contrast to purely user-defined approaches as described in [2]).

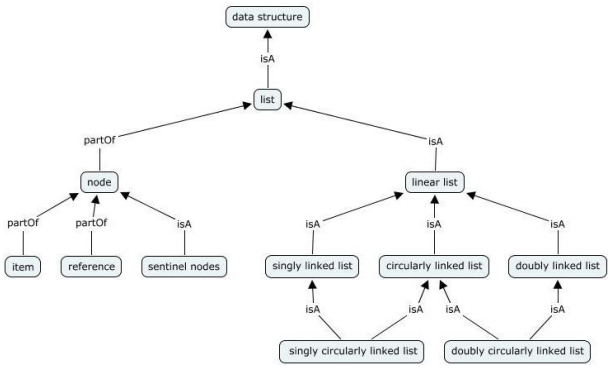

Figure 1: Part of the domain ontology used for the lecture on data structures

For each lecture, predefined tags were specified in a domain ontology that modeled the concepts and relationships of the subject domain (a standard technique today, going back to [40]). Part of the ontology for the lecture on data structure is shown in Figure 1. Using the terms defined in the ontologies, the lecturers were able to specify the concepts a Web resource described.

In addition to the information about the domain concepts, the lecturers were able to specify the instructional type of a resource [37] and its difficulty level. In order to minimize the chance that tags of other users of the social bookmarking service would interfere with our predefined tags, we prefixed the tags with our own character sequence. All in all, we used the following tags (with a different prefix):

- `sjtu:type:TYPE`, where `TYPE` is one of `definition`, `example`, `exercise`, `elaboration` and `introduction`.
- `sjtu:kp:CONCEPTID`, where `CONCEPTID` is the identifier of a concept as defined in the domain ontology.
- `sjtu:difficulty:VALUE`, where `VALUE` is one of `very_easy`, `easy`, `medium`, `difficult`, `very_difficult`.

The learning management system used by NEC employs the above domain ontology for the organization and presentation of learning resources. For each concept, the learning management system presents the available resources on a dynamically generated Web page. The resources can be especially authored for the learning management system, but also include resources that were bookmarked in the social bookmarking service. The learning management system retrieves these resources by using the API provided by social bookmarking service. This simple mechanism allows the learning management system to include resources found in the Web.

This work is comparable to previous research on open corpus hypermedia [20]. The basic principle is the same: a domain description is linked with resources that describe the concepts of the domain. This domain knowledge is then exploited by the learning management system, which distinguishes our work from usages of social bookmarking as described in [2], where groups of lectures use a joint collection of bookmarks.

One lecturer who used the prototyped appreciated the ease of adding and collecting additional resources so much that she used it in an unexpected way by asking her students

to add resources. Her course, "computer networks", was a small course attended by 20 students. Despite the enthusiasm of the lecturer, students made little use of the tool, only a total of eight resources were added. The lecturer attributed the limited participation to the fact that the course content followed a comprehensive textbook and there was no real need for additional resources. Our hypothesis is that in a course without good textbooks, the degree of participation will increase. The lecturer will test this hypothesis in a new lecture.

The important point of this project for this paper is the effort spent in realizing the prototype: the implementation was almost trivial. For the basic functionality, we used the service del.icio.us that allows access via API. On the learning management system side, we only had to add code that performed the lookup of the additional resources (including a cache in order to minimize load) and dynamically added the links to the resources. By building on the functionality available in the Web 2.0, we were able to assemble a prototype in very little time. Due to the popularity of the tool, it is now reimplemented within the NEC learning management system, with the specific functionality identified as relevant by the lecturers (e. g., extended by a grading system).

The next session summarizes the lessons we learned from using Web 2.0 services for rapid prototyping of technology-enhanced learning applications.

4. LESSONS LEARNED

The two examples of micro-blogging and social bookmarking allowed us to gain practical experience regarding the usage of Web 2.0 for learning. We will first discuss the two examples from the viewpoint of the analysis of Web 2.0 principles applications for learning done in the first part of this paper. Then, we elaborate on the suitability for rapid prototyping of technology-enhanced learning applications (as described the second part of this paper).

4.1 Learning in the Web 2.0

Our experiments have shown Web 2.0 services indeed stimulate active participation (principle "individual creativity"). Participation in the micro-blogging service was high and continues until four months after the lecture has finished. Usability of the services was judged as being rather good. About 75% of the microblogging users reported that registration and usage of the service was easy. This supports our claim that using existing Web 2.0 services can hold advantages since the burden of designing an easy to use interface is taken from the researcher.

An analysis of a questionnaire (83 participants) showed that three quarter of the students liked to use the service; about 50% used it at least once a day or more often. Only 5% disagreed to the statement that the usage of the microblogging service improved the overall atmosphere of the course, and again only 5% did not find that the microblogging improved the sense of community. 94% had the impression that they were able to improve their English.

The social dimension ("power of the crowd" and "long tail") was important, both within the course and outside. Within the lecture, we found that the students encouraged each other to participate: in some weeks they held "competitions" who contributes the most. Some of the micro-blogging messages show that students had conversations among each other, thus communication was not only one-way. As a result, despite being a distance course with optional attendance of class, a sense of community was created. Students also established contact to external people, e. g., native speakers (50% of the students according to the questionnaire).

However, we could also observe that unconstrained active participation results in distraction: e. g., in the microblogging service, students posted messages in other languages than English. Additionally, some users seemed not to be aware (or not to care) that their messages were readable by all other users and posted pejorative messages ("I'm too fat", "My boss is an idiot"). It is therefore important to note that although Web 2.0 applications fulfill their goal of stimulating participation, their usage in a classroom does not relieve the teacher of his role as a moderator.

The problem that the openness of a service can potentially interfere with the intended functionality of the learning application that uses the service was also relevant for the social bookmarking application. There, in theory, foreign users might add resources using the same tags, but with a different semantic. In this concrete example, we avoided the problem by using specially marked tags. This is not a bullet-proof solution, but minimizes potential problems.

We also noted that mobile access to the Web 2.0 is still to come (Principle "independent access"). Most students used the standard Web access to the services. In the microbloggin service, only about 10% used the mobile phone regularly to send/receive messages. Paradoxically, one problem with receiving the messages via SMS was the success of the service: on some days, more than 50 messages were sent by the students, quickly cluttering any SMS inbox.

To our knowledge, the students did not use any of the advanced assembly features ("architecture of assembly"), such as the integration of the services in their homepage or blog. We believe that this is caused by the students still being unfamiliar with such possibilities, and that we did not provide instructions on how to do so. However, we did observe that students used standard personalization features, such as uploading background pictures and personal avatar pictures.

4.2 Web 2.0 for Prototypes

The exploitation of existing Web 2.0 services for our research allowed to realize running prototypes quickly and relieved us from the burden of technical details such as managing user load and of the difficult task of designing user interfaces. Nevertheless, such an approach is not without drawbacks and one needs to be aware of potential shortcomings.

First of all, in the "architecture of assembly" one becomes dependent of an API controlled by a third party. This is more severe than using a programming library, since API changes directly affect the application: the perpetual beta stage of Web 2.0 applications has the consequence that one cannot download a specific version and stick to it. Similarly, conditions of use can change. During our Twitter usage, the service introduced rate limits that regulated the amount of requests per hour a client could send. This conflicted with our goal to download all of the students' messages.

However, for most part Web 2.0 service owners aim at keeping close and good contact to their users, including developers. The "perpetual beta" of Web 2.0 applications aims at increasing the value a user gets from using the service. Additionally, the architecture of participation brings

forward an interest of developers in new usages of their service. Thus, in our experience, they are very interested in feedback and open to suggestions. For instance, most sites will make exceptions to rate limits upon request.

Having to rely on external APIs also involves the problem that sometimes not all required functionality is implemented. However, as long as the wished-for functionality is there in principle (as a rule of thumb: as long as it is achievable by the Web interface), it is possible to artificially "extend" the functionalities. In the micro-blogging prototype, the API allowed only to retrieve the last 20 messages of each user, which sometimes was insufficient. Despite the API limitation, the Web interface allowed to browser all messages of a user. Thus, we implemented a crawler that retrieved the necessary messages by parsing the Web page.

An additional problem raised by using services not under direct control concerns user identification. More often than not, each service requires the creation of a new login; only rarely can existing accounts on one service be reused for a different service. The non-existing single-sign-on is a well-known problem in the Web, however decentralized approaches such as OpenID[14] might answer these problems. But currently, students still need to create their own accounts and these accounts needs to be matched to the student accounts used within the educational organization.

One drawback of the "perpetual beta" is that user interfaces will change. Usually the change improves the service, but still, the changes need to be reflected in user manuals written for the students. During our usage of the microblogging service, the user interface and underlying metaphors were changed twice. Since the changes happened after the students had become familiar with the service, there was not immediate need for adapting the user manual. The situation would have been different if the change had taken place during the start of the lecture.

Depending on the degree of integrating of the third party Web 2.0 services and one's own application, security becomes an issue. A client application such as an learning management system cannot directly control the service provider and depends on his reliability. This matter is complicated when mashups or widgets are used since these include additional sources of vulnerability [22].

In our experiments, we did not use the "diverse data on an epic scale" for learning support, but are using it for research: we have now a corpus of 5400 Twitter updates to be analyzed for linguistic patterns, such as typical language learning problems. For instance, we were able to identify typical mistakes by Chinese learners and are now preparing special Twitter lessons to overcome these problems.

5. CONCLUSIONS

This paper made the following contributions: we showed that insofar as one can speak of an innate pedagogy of technology, the Web 2.0 pedagogy is best associated with constructivism and social learning. This claim is based on an analysis of the technological principles of Web 2.0. Thus, our work extends prior research that explores the potential of Web 2.0 for education in general by [19, 2] and explains Web 2.0 principles for an educational audience [6].

Furthermore, we showed that Web 2.0 yields potential for research on technology-supported learning. By exploiting existing Web 2.0 services and thanks to the openness of these services, it is possible to assemble in limited amount of time complex prototypes that allow to assess the validity of research hypotheses. We discussed two example applications that illustrate this claim and presented the lessons we learned from these examples.

To summarize, Web 2.0 offers an intriguing and unparalleled wealth of functionality at a very high level. The exploitation of this functionality offers a high potential for the future of technology-enhanced learning. However, it is important not to forget that even if technology can be inspiring, the main focus in e-learning should still lie on the needs of the learner.

[14] `http://openid.net/`

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