Harnessing Collective Intelligence in Personal Learning Environments

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Abstract—The Personal Learning Environment (PLE) driven approach to learning suggests a shift in emphasis from a teacher driven knowledge-push to a learner driven knowledge-pull learning model. One concern with knowledge-pull approaches is knowledge overload. Thus, there is a crucial need for knowledge filters to help learners cope with the problem of knowledge overload. In this paper, we present the details of PLEM as a Web 2.0 driven service for personal learning management, which acts as a knowledge filter for learning. The primary aim of PLEM is to harness the collective intelligence and leverage social filtering methods to help learners find quality knowledge nodes that can populate their PLEs.

Keywords—personalization; personal learning environment; web 2.0; collective intelligence; social filtering;

I. INTRODUCTION

One of the core issues in Technology Enhanced Learning (TEL) is the personalization of the learning experience. There is a shared belief among TEL researchers that TEL models require a move away from one-size-fits-all models toward a learner-centric model that puts the learner at the center and gives her control over the learning experience.

In recent years, the concept of Personal Learning Environment (PLE) has been widely discussed among TEL researchers, as a natural and learner-centric model that supports the self-directed learning process by surrounding the learner with the environment that matches her needs best. PLE-driven TEL approaches have been proposed as an alternative to traditional learning management system (LMS)-driven TEL initiatives, which, in many cases, have failed to achieve a performance improvement [1]. While an LMS adopts a knowledge-push model and is concerned with exposing learners to content and expecting that learning will happen then, a PLE takes a knowledge-pull model. Learners can create their very own environments where they can pull knowledge that meets their particular needs from a wide range of high-value knowledge sources.

One concern with a PLE-driven knowledge-pull approach to TEL is knowledge overload. Thus, services that enable learners to widen their personal knowledge network circles to embrace new knowledge nodes become crucial. The collective intelligence which has become the driving force behind Web 2.0 provides one possible solution to deal with the problem of knowledge overload. Knowledge filters, driven by collective intelligence, can assist learners in locating valuable knowledge nodes to enrich their PLEs. This paper presents the implementation and evaluation details of PLEM as a Web 2.0 driven service for personal learning management, which acts as a knowledge filter for TEL. The primary aim of PLEM is to harness the collective intelligence and leverage social filtering methods to help learners locate quality learning entities.

The remainder of this paper is organized as follows. Section II introduces the theoretical background of PLEs and describes the associated problem of knowledge overload. In Section III, we explore how the concept of collective intelligence can help overcome the problem of knowledge overload. We follow in Section IV and Section V with the implementation and evaluation of PLEM as a Web 2.0 service that supports self-directed learners with knowledge filtering. And finally, we summarize our findings in Section VI.

II. PERSONAL LEARNING ENVIRONMENTS

Self-directed learning provides a base for the establishment of a learning model that goes beyond curriculum and organization centric models, and envisions a new one characterized by the convergence of lifelong, informal, and ecological learning within a learner-controlled space. In recent years this way of learning is increasingly supported by responsive, open, and personal learning environments, where the learner is in control of her own knowledge development and learning pace.

The Personal Learning Environment (PLE) concept translates the principles of self-directed learning into actual practice. From a pedagogical point of view, a PLE-driven approach to learning supports a wide variety of learning experiences outside the institutional boundaries. It puts the learner at the center and gives her control over the learning experience. From a technical point of view, a PLE-driven approach to learning gets beyond centralized learning management systems. A PLE suggests the freeform use of a set of lightweight and loosely coupled tools and services that belong to and are controlled by individual learners. Rather than being restricted to a limited set of services within a centralized institution-controlled system, the idea is to provide the learner with a plethora of different services and hand over control to her to select, use, and remix the services according to her needs. A PLE does not only provide personal spaces which are controlled by the learner,
but also requires a social context by offering means to connect with other personal spaces for effective knowledge sharing and collaborative knowledge creation within open and emergent knowledge ecologies.

A PLE-driven approach to learning also suggests a shift in emphasis from a knowledge-push to a knowledge-pull learning model. In a learning model based on knowledge-push, the information flow is directed by the institution/teacher. In a learning model driven by knowledge-pull, the learner navigates towards knowledge. One concern with knowledge-pull approaches, though, is knowledge overload.

### III. GET Knowledge TO LEARNERS

In a world of unlimited space and abundance, learners are increasingly brought into near limitless choices of almost everything. The latest evolution of the Internet has offered abundance accesses to learning sources. These include various types of learning materials, countless opportunities of collaborative learning, and many communities and networks where learners with common interest can meet and share ideas. Nowadays, learners now have more choices to enhance their learning experience. However, searching for particularities within the continuously increasing knowledge resources can take a great deal of efforts and time. The collective intelligence can play an essential role in these cases. Under the right circumstances, groups of people are occasionally more intelligent than their members are as individuals [2]. Harnessing collective intelligence has become the driving force behind Web 2.0. Through its means of filtering, rating, feedback, reviews, criticisms, and recommendations it is possible to differentiate between valuable and non-relevant. For instance, Amazon’s review and recommendation system, YouTube’s rating scheme, Google’s PageRank algorithm, eBay’s feedback, Digg’s voting are successful attempts to harness user’s collective intelligence on the Web.

In a PLE-driven approach to learning, there is a crucial need for knowledge filters that build on collective intelligence to help learners find quality knowledge nodes. In the knowledge management literature there is often a distinction between explicit and tacit knowledge. Explicit knowledge (or information) is systematic knowledge that is easily codified in formal language and objective. In contrast, tacit knowledge is hard to formalize, difficult to communicate and subjective [3]. Hence, we can distinguish between two types of knowledge nodes:

- **Explicit knowledge nodes** are information assets that are captured in a variety of forms, such as texts, images, audios, and videos and stored over distributed information repositories.
- **Tacit knowledge nodes** are people performing in diverse, frequently overlapping social domains, who act together and help each other see connections.

In the next sections, we present the details of PLEM as a Web 2.0 driven service for personal learning management, which embraces learners’ collective intelligence and acts as a knowledge filter to provide an effective way for learners to extend their PLEs with quality tacit and explicit knowledge nodes.

### IV. PLEM IMPLEMENTATION

PLEM acts as a knowledge filter for learning. It taps the collective intelligence by following what learners on the Web do with learning elements and translating that into relevant search results. In PLEM, we differentiate between four types of learning elements which represent explicit and tacit knowledge nodes: learning resources, learning services, learning experts, and learning communities. An abstract view of the PLEM filtering module is depicted in Figure 1.

![Figure 1. Abstract View of PLEM](image)

Learners can act as guides in the way they interact with learning elements on the Web (e.g., bookmark web pages, tag resources, recommend items, review books, comment on blogposts, trackback sites, share videos, vote on news). The idea is to aggregate this distributed local filtering behavior to improve the search for and recommendation of relevant learning elements.

The idea behind the PLEM filtering mechanism is quite simple. Each distributed filtering action on a learning element from the Web (e.g., comment, link, save, like, rate, vote, view, share) counts as one “vote” for that learning element. The popularity of a learning element is then measured by aggregating the number of “votes” for that learning element, gathered from multiple distributed Web 2.0 services.

The PLEM filtering module is based on the mashup concept, which is a core technology in the Web 2.0 movement. It not only uses data collected from PLEM users, but also data from third party service providers. As shown in Figure 2, for each learning element in PLEM, different interaction metrics...
are computed. These metrics currently include PLEM saves and ratings, Twitter tweets, Facebook clicks, shares, likes, and comments, Friendfeed entries and likes, Digg votes, and Google blog trackbacks. This information is gathered using open APIs of the related services, as illustrated in Figure 3. It is then used by the PLEM ranking algorithm to rank learning elements based on their popularity on the Web. Thereby, the rank value of a learning element is determined by summing up the "votes" for a given learning element retrieved from various services.

V. PLEM EVALUATION

This section shall present the evaluation of PLEM based on learner feedback. We begin with a discussion on a software evaluation model, which serves to set up a theoretical model for the evaluation of PLEM.

A. Evaluation Model

The evaluation strategy of PLEM was based on the I/S Success Model proposed by DeLone and McLean [4], [5], as shown in Figure 4.

According to DeLone and McLean, system quality and information quality singularly and jointly affect both use of the system and user satisfaction, which are reciprocal constructs; that is the amount of use can affect the degree of user satisfaction (positively or negatively), as well as the reverse being true. The use of the system and the user satisfaction produce an individual impact (i.e. user’s performance), which in turn produces an organizational impact (i.e. performance of the whole organization).

System quality describes how good the system is in terms of its operational characteristics and performance. It also deals with how fit the system is in fulfilling the requirements. This can be increased by giving more test suites that cover all possible input for the system. Information quality defines how good the system is in terms of its output. Measures of information quality are typically done from the user's perspective, and are thus typically subjective. Furthermore, the measurement of information quality is often included as part of the measures of user satisfaction [4, pp. 65-66] which is a construct that measures perceptions of the system by users. It is one of the most widely used single measures of I/S Success [4, p. 69].

To measure its system quality, PLEM has been passed through a series of test suites to ensure that it fits the requirements. To capture its information quality, PLEM has been set up as a public website (http://subprogra.informatik.rwth-aachen.de:8180/PLEM/), giving free access to all learners to interact with the service. Besides, a questionnaire has been given out to get conclusion on the usability of PLEM.

B. Usability Evaluation

With particular reference to information systems, usability is reflected in the current draft international standard ISO.
9241-11. It suggests that the measures of usability should cover [6]:

- effectiveness (the ability of users to complete tasks using the system, and the quality of the output of those tasks),
- efficiency (the level of resource consumed in performing tasks),
- satisfaction (users’ subjective reactions to using the system).

There are several methods for testing usability. The most common methods are thinking aloud, field observation, and questionnaires. In this work, we used a questionnaire as usability testing method. Learners were asked to carry out a set of benchmark tasks written as scenarios and then report their impressions on the questionnaire provided to them at the beginning. The questionnaire was divided in various subsections dealing with the general background of the evaluator, the overall system evaluation, the evaluation of the filtering functionality implemented in PLEM, and final remarks.

Questionnaires were sent to 25 evaluators with various backgrounds and 22 answers were received. The results of the feedback are discussed in some detail in the following subsections.

1) Learner Profiles and General Questions: Altogether, 13 females and 9 males tested the service, all of them students at the age range 20-28 years. Most evaluators were academic learners in Europe. Out of 22 feedback forms returned, only 1 evaluator came from outside Europe, more specifically from Indonesia. The majority consisted of graduate students enrolled at RWTH Aachen University in various disciplines. The background of the evaluators varied: 9 evaluators came from a Computer Science background and the rest from other majors like Science, Electrical Engineering, and Mechanical Engineering. Evaluators were asked to choose between four learning topics, namely Quran, Badminton, Photography, and Cooking (see Figure 5).

As a starting point, all evaluators relied on search engines for finding relevant learning materials. Having found interesting materials, 3 of them use social bookmarking tools to share the materials with others, 11 use social networking tools and the rest just use email as a sharing medium. 16 out of 22 evaluators had no prior experience with social bookmarking tools. And, only 12 out of 22 evaluators are familiar with social recommendation features (save, rate, vote, like, etc.) provided by online services.

2) Overall User Evaluation: The overall system evaluation section includes 20 questions, which are a subset of the 50-question database of the Software Usability Measurement Inventory (SUMI) - a rigorously tested and proven method of measuring software quality from the end user’s point of view [7]. SUMI is mentioned in the ISO 9241 standard as a recognized method of testing user satisfaction. The SUMI database embraces the user’s opinion towards the usability of the system, including measures such as learnability and understandability, the reliability of the system, such as fault tolerance and recoverability, the maintainability of the system, such as stability, the efficiency of the system such as time and resource behavior, and the functionality of the system, such as accuracy and suitability.

For the evaluation of the results of the SUMI questionnaire, the System Usability Scale (SUS) [6], which is based on a 5-grade scale, and yields a single number in the range from 0 to 100, has been used.

The final scores for the overall satisfaction of 22 evaluators of PLEM turned out to be in the range between 38.5 and 77.27 points. Out of the 20 SUMI questions used, only one was below 50 points. Two were between 50 and 60 points. Ten were between 60 and 70 points. The other seven were between 70 and 80. This results in an average user satisfaction of 65.90 points out of 100 points, or approximately 66%.

From the results in this section, we derived three questions with relatively low scores. These are "I prefer stick to other systems that I know best", "This system has a very attractive presentation", and "This system has helped me overcome any problems I have had in using it". This result shows that:

- PLEM needs improvements in terms of system learnability and understandability.
- PLEM needs enhancements in the presentation of the user interface.
- PLEM needs to provide more adequate error messages, (input) validations and error prevention mechanism to support learners.

There were two questions that received the highest score, namely "The interface is simple, clean and there is no unnecessary element" and "The icons and labels are self-described". Respectively, these questions are given a total
score of 77 and 76, which means that most evaluators averagely chose between “generally agree” and “strongly agree”. Thus, the PLEM interface can be considered simple and intuitive.

3) Functionality Questions: The functionality questions attempted to gauge the evaluators’ impression of the filtering and ranking features provided in PLEM. As shown in Figure 6, most of the evaluators found that the result of the ranking of learning elements in PLEM is appropriate. The majority also considered that users’ interactions within PLEM (i.e. saves and rates) and votes gathered from various third party services play a significant role to determine the popularity of learning elements in PLEM.

4) Concluding Remarks from the Evaluators: The evaluators were also asked to give their impression of the effectiveness of PLEM in its original intent of being used for knowledge filtering in a self-directed learning environment. As shown in Figure 7, most of the evaluators found PLEM to be generally suitable for self-directed learning purposes. 16 out of 22 evaluators agreed that PLEM has the potential to be used as a knowledge filter for learning. One evaluator who was not sure about the same, pointed out that, due to the limited number of the learning elements available in PLEM, she was not able to discover learning elements that were really new to her. This is, however, a common problem in all social software services, which are expected to get better, the more people use them.

VI. CONCLUSION

In this paper, we discussed the concept of Personal Learning Environment (PLE), which offers a learner-centric view of learning and suggests a shift from knowledge-push to knowledge-pull approach to learning. We continued by discussing the associated problem of knowledge overload, and highlighted how collective intelligence, when the whole is greater than the sum of its parts, can help learners deal with knowledge overload. We then presented the design and implementation details of PLEM, a Web 2.0 driven service for personal learning management that acts as a knowledge filter for learning. The primary aim of PLEM is to harness the collective intelligence to help learners find quality knowledge nodes. Finally, we discussed the evaluation procedure that was adopted and its results. A questionnaire was designed to get conclusion on the usability of PLEM, in terms of effectiveness, efficiency, and user satisfaction. In general, the evaluators found the ranking mechanism in PLEM to be satisfactory indeed and reported their willingness to use PLEM for knowledge filtering purposes in personal learning environments.

REFERENCES


