Learning by doing as mobile with a Urban Computing Lab

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Abstract: For years the most significant feedback from hypermedia students in Tampere University of Technology (TUT) had noted a lack of examples from real-life situations, even if teachers had used cases from real hypermedia projects as theoretical learning materials. In response to feedback the Urban Computing Lab (UCL) was designed and implemented at the Hypermedia Laboratory in TUT in purpose to support teaching and learning of design and evaluation of web-based services. For motivating students to learn it is important that the learning consists of authentic problems to solve (situations) and factual connections (contexts) to theory. The UCL is a web-based service to collect a large amount of rich, real-time information about quality experiences in real-life situations and contexts where people are using web based services for various purposes. The important component of UCL service is a visualization tool that helps students and researches to understand and analyze the large amount of data by offering visualizations based on social network analysis (SNA). The quality experience of web-based service is a phenomenon with multilevel and multidimensional features. The UCL service with the visualization tool supports students to understand better the dimensions of quality experiences and their relationship to each other.

Learning hypermedia by doing

Teachers in the Hypermedia Laboratory at Tampere University of Technology in Finland collected feedback from students to develop learning materials and teaching methods in their hypermedia courses. The most significant feedback for years had noted a lack of examples from real-world situations, even if teachers had used cases from the Internet and real hypermedia projects as theoretical learning materials. Hypermedia means in teaching modeling and organizing information and services so that the real users, tasks, and the usage context are appropriately acknowledged. Typical course topics are, for example, accessibility, web content production and design, structured documents, usefulness of web-based services and programming of hypermedia. Students can focus on either the technical implementation of structured information or general design and management of hypermedia projects. The teachers of hypermedia at TUT are also active researchers of the domains concerned.

From the learners’ point of view the learning should consist of both real-world problems to solve (situations) and factual real-world connections (contexts) to theory, which motivates students to learn. The concepts of context and situation are in that case related to place, time and even the ways in which learning occurs; learning occurs in situations (situated cognition) and contexts open up opportunities for meaningful learning from real world problems. Meaningful learning makes students to be more motivated, active and intentional. For assure this kind of meaningful learning teachers can use examples and tasks to simulate and demonstrate complex authentic problems. Meaningful learning includes active, constructive, collaborative, intentional, complex, contextual, conversational and reflective dimensions. Such dimensions as transfer, motivation, volition and edutainment were also found in earlier research to enhance deep learning (e.g., Järvelä & Järvenoja, 2004; Entwistle, 1998; Jonassen, 1995; Jonassen, 1994; Kauppi, 1993).

In response to course feedback the Urban Computing Lab (UCL) was designed and implemented. The UCL is a web-based service to collect a large amount of rich information from real-world situations and contexts where people use web based services for various purposes. With visualizations teachers can identify from the collected data different kinds of user groups and use situations in various web services, including users’ quality experiences. They can also take screen shots of visualizations to illustrate the phenomenon to students. The purpose of the UCL is to assess the variety of quality of the web-based services by a systematic analysis of the information collected. The results help students to understand how and why different users prefer different properties of web services and why
users’ feedback on quality issues differs. The results also help designers to make prioritized decisions on improving the quality of web services.

**Quality experiences**

Usually an evaluation of web service quality is based on research in HCI (human-computer interaction), psychology or in some cases pedagogy as well as on evaluation research, which has its roots in the theory of usefulness of computer systems. Usefulness of web-based services includes usability and utility sections. The framework is needed to define the factors critical to the implementation of web services for a varied group of users. The main issues within this evaluation framework are usability, added value as well as accessibility and informational quality of web services (e.g., Silius & Tervakari, 2007; Silius et al., 2003; Forsblom & Silius, 2002; Nielsen, 1993).

Usability means that the user interface of a web-based application must be easy and effective to use so that the user can concentrate on the information content instead of the interface. When software is usable it is easy and efficient to use, easy to remember, has few errors and it is subjectively pleasing (Nielsen, 1993). The added value of web services can be evaluated as in conventional services. Is there something special or something new for users? An essential part of quality is also accessibility, because web design today is designed for individuals in various contexts with different devices (Foley & Regan, 2002; Burgstahler, 2002). The fourth part of quality is the informational quality of any web service. To be of high quality the informational content of a web service should meet the five main criteria: accuracy, authority, objectivity, currency and coverage (Liu, 2001; Albion, 1999; Tergan, 1998.)

In addition the foregoing viewpoints quality experiences of web services are also subjective and depend on user’s personality, expertise, needs and use situation and context. Therefore rich and detailed information on authentic use situations and related factors are needed to improve the design and implementation of web services. Reliable evaluation of web services also entails observing users in authentic situations. Usually information is collected by using for example questionnaires, use diaries or with interviews (e.g., Fulton Suri, 2003; Höök et al., 2006). The use situations and context have become more complex because of pervasive computing technologies, which have made the usage of mobile web services possible. Smart phones (such as the Nokia N95, Nokia N810, tablet PS’s and iPod Touch) and Internet-enabled personnel digital assistants (PDAs) enable users to connect to services more and more outside the homes or workplace and outdoors in urban areas (Kindberg et al., 2007; Kjeldskov & Paay, 2006). Therefore novel methods are needed to observe mobile usage.

To obtain reliable information on the situation and context of use, users’ individual manners and skills as well as the status quo of the web service and network connections should be taken into account. It should be remembered that every case of usage is unique, but there are similarities and differences between them, including permanent psychological and physiological traits of human beings like memory, perception, sense, basic needs and cultural factors (language, norms and habits) influencing to human behavior. Along with permanent factors there are unique contextual and situational factors such as the meaning of use, user’s individual skills in using web services, place and device for using the services as well as conditions in the use situation with regard to social aspects and emotions, which affect quality experiences.

It has been found that there is a relation between users’ emotions and rational behavior. Positive and approving emotions have a positive influence on information processing, creativity, thinking, interaction and even immunology systems. A positive and approving emotion also causes users to withstand some minor usability problems in web services whereas negative emotions have a negative effect on experiences of using web services (e.g., Picard, 1999; Norman, 2002; Surakka, 2004).

**Urban Computing Lab**

A trend to use social media to add digital tags to a map connecting to existing physical and social contexts and to share information as well as comment on it, facilitate the use of a new kind of approach to teach hypermedia. (E.g. Kjeldskov & Paay, 2006) UCL is a web-based service developed for the mobile collection of a large amount of rich real-time information about emotional, contextual and situational dimensions of quality experience. With the UCL students can easily save use information from any kind of web services. The information collected can be classified into five domains: general, physical, social, action and affective (e.g. Hansen & Bouvin, 2009):
• General level: demographic information, user’s experience of use web and a certain web service
• Physical level: for example geographical information and tags, time stamps, photos, technical information about devices and network connection
• Social level: description of a social situation (is the user alone, using the service with a friend or are there any people around if she/he needs help)
• Action level: information which describes users’ actions (what a user is doing, which web service he/she is using and the purpose of use, success of use)
• Affective level: information about a user’s feelings and emotions (overall and connected to use).

Geotagging and annotation are new ways to contribute and share information and interests. Only a short-term ‘lunch break participation’ is needed. Ames and Naaman (2007) investigated people’s motivation to tag in mobile and online media. They found that there are differences between users in how and why they tag and annotate. There are categories: social vs. personal and affective vs. functional. Social/affective individuals like to share information and feelings with friends and family members, personal/functional ones like, for example, to search for information tagged earlier whereas social/functional people like to share their tagged information with others. (Ames & Naaman, 2007)

The UCL is first of all a tool for students to do their weekly exercises and practical coursework. The UCL is device independent, so it could be easily used on laptops, mobile phones or PDAs. In the area of Tampere city centre there is ‘Langaton Tampere’ WLAN (Wireless Local Area Network) for the personnel and students of both universities, the University of Tampere and Tampere University of Technology (Langaton Tampere, 2008). Nowadays, when WLANs and mobile devices are widely used, mobile web services are also used, for example in cafes, shopping centers, libraries and parks (Kindberg et al., 2007). With the UCL students can collect use information just on time in the context where the service is used even by mobile means. This should guarantee more authentic information about use and perceived quality.

The advantages of the UCL are:
• Authentic contextual and situational information can be collected as ‘fresh’ as possible, so there is no need for memorizing or notes
• The information collected is digital, so further processing of the data such as integration into other information or data mining is easier
• It is easy to collect this kind of information which otherwise could be laborious, for example information about geological places, technical details of devices or user interfaces or operating systems
• Students need not be experts on research in the field to understand the overview of visualized data illustrating different kinds of user groups and use situations of various web services with users’ quality experiences.

From a technical point of view the UCL will utilize options for the mobile saving of geo and contextual information. Later users can enrich the information in many ways (with pictures, videos, descriptions etc.). As the picture below shows, there are geotags over the map. Each tag represents the use of various web services. The users made a note of their feeling and described the situation of use. In the example presented the user had tried to a buy train ticket by smart phone, but did not succeed. She/he is disappointed, but at the same time he reported that he was in a hurry. Later she/he can go back to the UCL to enrich the description. Because the user has is logged in with her/his official username at TUT the information on the user such as name, age, sex, degree program etc. is also available. (See Figure 1)

As described previously, the UCL was used to collect log data on different kinds of user groups and use situations of various web services with users’ quality experiences. The data can be analyzed with Social Network Analysis (SNA) methods that enable enriched network information production. Based on log data and together with SNA methods different visualizations can be produced. Visualizations can be used to support the analysis of different user groups (e.g. Huhtamäki et al., 2009). Another target of SNA analysis together with proper visualizations is to understand and detect changes and weak signals, to gain an overall view of the use of web services as a whole, and to identify differences and similarities between groups. With visualizations teachers can observe from the collected data different kinds of user groups and use the situations of using various web services
including users’ quality experiences and take screen shots to illustrate the phenomenon to students. (See Figures 2 and 3)

In the SNA matrix algebra together with graph theory constitute the background of methods used in the analysis. The object of study is human networks consisting of people and the relationships between them. The target is to find not only some deeper information about the actors in the network under study, but also some knowledge about the connections or similarities between actors and the structure of the network as a whole. The data sample depends on the network itself and considered the context or network action. In web-based systems collected log data can be reprocessed so that sample data is usable and relevant for SNA in finding answers to certain questions. Furthermore, graph theoretic and matrix models of network can be produced to be used e.g., in visualizing network evolution or in clustering network actors in a certain way.

In SNA visualizations play an essential role in the presentation of analysis results. Multilevel information on the network can easily be presented using visual images of the network. Different visualizations can show different information and in general it is not possible to visualize all information in one frame. Using separate layouts for network visualizations e.g., network structure and hierarchy can be distinguished and visualized much more appropriately. Basic graphs with vertices connected using edges or arcs are suitable for visualizing network structure and general overview, but using specific blockmodels and dendrograms (Wasserman & Faust, 1994) actor positions and actor hierarchy can be shown.

An interactive SNA report containing a sociomatrix, SNA figures such as user centrality and prestige (e.g. Wasserman & Faust, 1994) and a visualization of the user neighborhood shown to the user can be used in several ways in trying to modify the network. For example, if some groups are formed separately but they share a common interest visualization can be used as a tool to bring these two groups closer to each other if necessary. The same idea also works for individual users. (See Figures 2 and 3)
Visualizations can be considered as tools for data mining. The views of the collected data produced illustrate different kinds of user groups and use situations of various web services with users’ quality experiences. After that qualitative methods can be utilized to obtain more information on the phenomenon of interest. In the case of the UCL qualitative research has a special value for investigating complex and sensitive issues. For example, if the interest is in how people view topics like motivation to use web services, privacy in web services or added value in mobile use of services qualitative analysis interview data for example is needed. Qualitative methods enable a profound understanding of how people think about these topics, but without data mining with the SNA method and descriptive visualization achieving such understanding would be laborious.

As an example in Figures 2 and 3 we present SNA based visualizations of train ticket service usage. The SNA analysis was done together with qualitative research on users’ quality experiences. Thus two different figures were made based on reported user satisfaction. There are graphs for dissatisfied users (Figure 2) and satisfied users (Figure 3). The SNA graph drawing was done using an example of the data and the special SNA software Pajek (1). For the graphs Fruchterman-Reingold 2D layout was used.

As can be seen in the figures, there are connections between dissatisfied users and certain services used. Thus these users form a cluster that can be studied as one network in finding reasons for unsatisfactory quality experience. It was found that the service was used in a certain area of the city. The mobile phone link in that area is known to respond slowly to mobile web requests, which made usage of the train ticket service impossible. Moreover, clusters can be found among satisfied users as well. The research found that the service was worked properly when it was used through a personal computer and accessed via direct Internet connection. It was also found that the service was used by rather many users in a café near the railway station.

![Figure 2](image1.png)  
Figure 2. Dissatisfied train ticket service users. Users in cluster 1 have used the same mobile phone link. Cluster 2 is isolated because of old browser usage.

![Figure 3](image2.png)  
Figure 3. Satisfied train ticket service users. Clearly the activity is much more intensive. Users in cluster 1 have connected to the service using a laptop computer in a certain café in the city centre and in cluster 2 at home.

**Discussion**

The purpose of this paper was to describe the concept of the Urban Computing Lab. The UCL is a web-based service to collect a large amount of rich information from real-world situations and contexts where people use web-based services for various purposes. The data is shown over a map to illustrate geo, contextual and situational tags and annotations. The UCL is a concept to collect any kind of contextual data for various needs. It can be changed to tag buildings, environment, events or, for example, traffic jams. The collected data can be analyzed using SNA methods and results shown as visualizations.
The UCL is used on courses where user centered design as well as evaluation of web services is taught. Nowadays, when web services are used more and more outsides of homes or workplaces everywhere outdoors in urban areas novel methods to observe mobile usage are needed. To design and implement high quality web services necessitates rich and detailed information of authentic use situations and related factors. Reliable evaluation of web services also requires observing users in authentic situations. The results help designers to make prioritized decisions to improve the quality of web services.

From the learners’ point of view the learning should consist of both real-world problems to solve (situations) and factual connections (contexts) to theory, which motivates students to learn. Utilizing new technology can also motivate students, because at TUT students studying hypermedia are more likely to be seen as early adopters of technology than students in other fields of study. The UCL will help teachers and hypermedia researchers to better understand the phenomenon. For example, will there be differences among students to use tags and annotations in UCL? Or will there be different kind of devices to use UCL and what kind of influence will the increasing use of smart mobile phones (such as the Nokia N95, Nokia N810, tablet PS’s and iPod Touch) have on mobile use of UCL and even on the use of different kinds of web services? It will also help look at how students can best learn from raw data or how they can get a meaningful representation of information collected during courses.

We contend that visualizations are a relevant way to show user positions in a certain network or context. Analytic information evaluated mathematically from the data can bring out some extra information about the real role of a user in the network studied. Visualizations and SNA figures still represent only a part of the complex network information. Thus students can only gain a few perspectives on the network. On the activity level the positions of users in a network do not tell enough, but when the significance of an activity is analyzed and reported the conception of the network becomes clearer. After that it is possible to gain a better understanding of the phenomenon for example by utilizing qualitative methods.

To achieve meaningful visualizations log data collection should also be designed and executed in a relevant way. The collected data should contain information that can be used in the analysis to respond to the research questions set. This clearly needs specifications for the log data format and structure. The more generalized the format is the more flexible analysis methods can be used in terms of SNA. The views and reports for end users produced through analysis should include relevant knowledge and at the same time clearly formalized so that the user can easily absorb the information needed. Visualizing and reporting obvious phenomena should be still avoided.

In this field technical applications with multiple variations are proper new research questions to be studied in the UCL. We maintain that the concept of the UCL can be applied in teaching and research in different fields of study. The visualizations of data gathered support students to build a holistic picture of a multidimensional phenomenon of quality experience, and to understand better the relationship of dimensions affecting quality experience. In addition the visualizations satisfy especially students with visual learning style. (Gardner, 1983.) The visualization tool of the UCL offers possibility to investigate quality experiences from several different viewpoints and an opportunity to experiment with new ideas, to find solutions to practical issues and to work “hands-on” with practical application. (cf. Kolb, 1984).

Earlier studies (e.g., Pohjolainen et al., 2007; Silius & Tervakari, 2007) have shown that there is variation in students’ motivations and ways of learning. Using new technologies in teaching motivates some students to orientate themselves more precisely and actively in the learning process. Therefore new methods offer a much more convenient way to learn and achieve better results. Thus the usage experiences of visualization tools similar to the UCL and SNA method based end user reports will be also researched in other projects (e.g., Erimenu.fi, Menumap, Finnish Children’s Parliament, TUT Circle, etc.) in Hypermedia Laboratory at TUT.

Endnotes
(1) Pajek is a Microsoft® Windows® based SNA software that is free for non-commercial use. http://pajek.imfm.si/doku.php
References

