Perspective and Contrast, Design Principles for Supporting Self-directed and Incidental Learning

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Abstract: This paper reports on a meta-analysis of two qualitative studies that use visualisations of user interactions in Web2.0 systems in order to support self-directed and incidental learning. This analysis focuses on the identification of design principles for supporting learning beyond the well structured conditions of educational institutions. The studies applied a reference architecture for context-aware systems together with a contextual framework that is based on the theory of situated learning. Although combining these concepts lead to satisfactory results, it appeared that the design of visualisations for supporting self-directed learning requires further constraints. The given meta analysis identified the two design principles "perspective" and "contrast". This paper discusses how these principles were present in both prior studies.

Keywords: learner support, Web2.0, self-directed learning, design principles, HCI, information visualisation
Categories: L.1.0, L.2.1, L.2.2, L.2.4, L.3.1, L.3.4, L.6.0, K.3.m

1 Introduction

Recently a new type of software tools has become popular on the Internet. These applications mark the advent of the Web2.0 [O'Reilly, 2005]. The Web2.0 stands for web-based services that allow their users to create and manipulate resources. Another aspect of the Web2.0 is that services are no longer considered to be standalone, but that they can be integrated into higher level services. The ability of connecting services into new applications attracts also the educational technology community. One track in the related discourse is related to personal learning environments (PLEs). PLEs are learner centred mash-ups of the learners' Web2.0 services [Wilson, 2006]. The idea of PLEs as integrated Web2.0 services is directly connected to the constructivist concepts of emergence and self-organisation [Von Glasersfeld, 1995]. This holds potential for supporting communities of practice and self-directed lifelong learning.

This paper is on a meta-analysis of two qualitative studies that use visualisations of user interactions in Web2.0 systems in order to support self-directed and incidental learning. The next section outlines the background and motivation of this study. It is followed by the research questions that are addressed by this paper and a brief description of the two studies that are analysed. The fifth section reports on the key results of the studies. It is followed by the analyses The following section analyses the two studies in order to identify design principles that can be applied for designing technological support for self-directed and incidental learning. This paper concludes with an outline of the practical constraints of applying the identified design principles.

2 Background

Self-directed learning is a key factor in the knowledge economy. The so called "knowledge worker" is by definition in a continuous learning process [Steward, 1997]. For knowledge workers and practitioners within weakly structured or emerging professional environments, the process of "self-directed learning" cannot be separated from practice. This type of development in practice is for many knowledge workers the prime context of learning, because traditional forms of formal and even non-formal education cannot meet their advanced and highly specialised learning needs. However, the connectedness of learning and practice holds the danger that the learning processes are no longer recognized [Bjørnåvold, 2000].

Self-directed or incidental learning depends on a person's ability to take initiative and to reflect on her or his learning actions [Knowles, 1975; Marsick, 2001]. Therefore, reflection is a factor for learning of professionals [Schön, 1983; Schön, 1987; Ertmer, 1996], where three types of reflection were distinguished: "reflection in action", "reflection on action", [Schön, 1983] and "reflection for action" [Ertmer, 1996]. For the autonomous learners, two aspects for supporting learning can be identified from the existing literature. Firstly, participation in a community of practice is relevant for sharing knowledge and developing ideas, concepts, and solutions [Lave, 1991]. Secondly, reflection is a meta-cognitive activity that is crucial for the personal learning process. Feedback is required to stimulate and support reflection [Butler, 1995; Ley, 2001; Ertmer, 1996]. However, even in communities of practice, feedback on the individual learning process is not guaranteed.

The theory of situated learning [Lave, 1991] states that learning is always situated in a context. While prior research in the domain of mobile and ubiquitous learning emphasises situated learning in terms of localised learning, the discourse on situated learning [Lave, 1993; Wenger, 1998] suggests a greater complexity [Glahn, 2009].
By analysing the work related to this theory, 6 contextual dimensions [Lave, 1993] and 12 context factors [Wenger, 1998] were identified (Table 1). The mapping of these dimensions and factors provides a conceptual framework for designing visualisation for providing contextualised feedback on situated learning, because it allows identifying the types of possible interpretations of the learning processes that can be expected for each context dimension. For example if the participation dimension is focused as the primary context dimension, it can be expected that learners relate meaningful learning experiences to the following factors: *presence*, *interaction*, *involvement*, *personal identity*, *communal identity*, *boundaries*, and *community building*.

Internet technologies hold great potential for supporting self-directed and incidental learning of individuals and communities [Wenger, 1998]. [Wenger, 2005] argue that Web2.0 services play an increasing role for facilitating communication and information organisation between the peers of a community of practice. This suggests that PLEs can provide suitable frameworks to connect individual learners and communities into learning networks for lifelong competence development [Koper, 2005]. However, this potential depends on the ability of a PLE to provide appropriate feedback for emphasizing the learning progress.

Lave, 1993 → Wenger, 1998 ↓	Process	Peers	Event	Partici-pation	Concept	World
Presence		X	X	X		
Rhythm	X		X			
Interaction		X		X		
Involvement				X		
Value		X			X	X
Connections		X			X	X
Personal Identity				X		
Communal Identity		X		X		
Relations		X				
Boundaries		X		X		X
Integration	X	X				
Community building	X	X		X		

Table 1: Contextual dimensions and contextual factor alignment

3 Questions of research

One of the key problems with technological support for self-directed and incidental learning is that the knowledge domain, the personal learning objectives, and the competence levels of the learners are not explicitly expressed and sometimes not even conscious to the learner. Under these conditions is information visualisation of learner actions is one approach to provide feedback on learning activities. Selecting and arranging relevant information of such feedback is not trivial. Therefore, the present study addresses the question about the generalisable design principles for providing contextualised and personal feedback in situated learning.

This has been motivated by the following research questions [Glahn, 2008a].

- What is the effect of different aggregators, strategies and indicators on the learning process and how can they get effectively combined and applied for supporting the learning process?
- How can a system collect data and aggregate contextual information in a way that it can provide meaningful information at the different stages of a learning process?

- What contextual information is relevant to support the learning process and does this information change throughout the individual learning process?

4 Method

This study analyses the findings of two earlier qualitative studies, in which visualisations were used to provide feedback on the participants' activity. The first study used embedded bar chart visualisations [Glahn, 2007]. This study used the team.sPace platform and analysed two types of bar chart visualisations of the participants' activities in relation to their engagement collaborating [Glahn, 2009]. One visualisation is a personal "activity counter"; the other is a "performance chart". The two visualisations were embedded in a peer information portal and liked to more detailed information and enable the participants to scrutinise the details about what is shown in the graphics. Figure 1 shows that the "performance chart" relates a learner's actions to the actions of the group, while the "activity counter" visualises a learner's actions without additional context. The only difference between the visualisation was the arrangement and presentation of information, while the underlying data was the same.

Furthermore, the explicit and implicit tagging of the team.sPace participants was analysed [Glahn, 2008b]. This second analysis focused on the differences among the participants in using the available information.

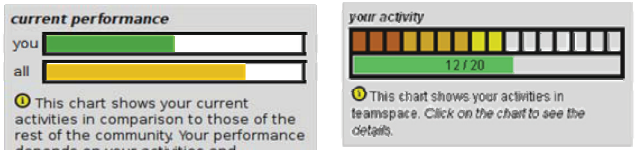

Figure 1: team.sPace indicators; performance chart (left), activity counter (right)

The second study analysed if a tag cloud of can stimulate reflection on tagging online resources [Glahn, 2008c]. For this study used the ReScope tag cloud, which visualises the global tag usage is represented in the font size and the recent tag usage is displayed in different colours (see Figure 2). The selected data sources are related to the context dimensions 'concept' and 'process'. Given to the conceptual framework presented earlier it was expected that the tag cloud stimulates equally reflections related to the three related context factors 'rhythm', 'value', and 'connection'. Furthermore, it was anticipated that the visualisation has no particular affinity to one type of reflection. In addition to the tag cloud the participants were encouraged to take notes about their reflections on the tag cloud. These notes were associated to the visible tag cloud in a way that the participants were able to revisit and reassess previous states of their tag cloud.

Both systems implemented the four layered architecture for context aware systems that has been proposed by [Zimmermann, 2005]. This architecture abstracts the information processing of context-aware systems into a sensor layer that covers the data capturing, a semantic layer that models the aggregation of the captured data,

a control layer that covers the processes of contextualisation, and an indicator layer that models the ways of how a context aware system responds to a user.

The systems were evaluated based on the user interactions with each system over a period of nine weeks in case of team.sPace and three months in case of ReScope. For both studies the participation was voluntary and none of the participants contributed to both studies.

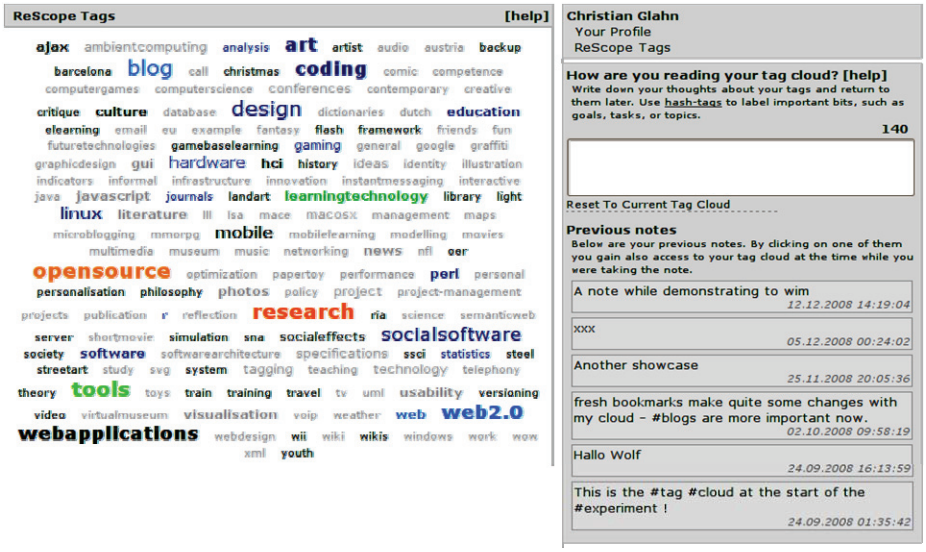

Figure 2: User interface of ReScope

5 Key findings

The team.sPace study focused on two aspects. The first aspect is the different perception of two activity visualisations among the participants. The second aspect concerned the differences in tagging and the usage of tagged resources. The results indicate that the performance chart was more engaging than the action counter for contributing participants. For non-contributing participants this visualisation appeared to be discouraging. The action counter appeared to be ignored by the participants. The results of the tagging activity suggest that the active tagging and the use of tagged resources refer to different aspects of interest, but cannot be related to the level of participation. While the perception of the provided differed among the participants working with different indicators [Glahn, 2009], the use of the available resources on the portal did not vary in the same extend [Glahn, 2008b].

In the ReScope study the participants in the study were encouraged to use the provided note keeping function to record their reasoning on their tag cloud. The notes provided by the participants were categorised regarding the three types of reflection of [Schön, 1983] and [Ertmer, 1996], and to the contextual factors that were suggested by the contextual framework. After cleaning notes without meaningful

content, all notes could be associated to the three types of reflections and to the expected context factors. The distribution of the notes that is shown in Table 2 indicates that the reflection notes show neither affinity to a particular type of reflection nor to a context factor. The results indicate that the dually encoded tag cloud stimulated reflection on the tagging activity of a learner. Using the highlighted tagging information supports the learners to evaluate and monitor the semantic structure of the resources that are found on the web. Because the participants' notes could be associated only to the predefined context factors it can be suggested that the concepts of situated learning can be applied for guiding the development of technological learning support.

	rhythm	*value*	*connection*	*Total*
Reflection on action	8%	18%	13%	39%
Reflection for action	5%	13%	8%	26%
Reflection in action	11%	8%	16%	34%
Total	24%	39%	37%	100%

Table 2: Association of notes to context factors and reflection types of the ReScope study (variations of totals due to rounding)

6 Discussion

The two studies analysed different visualisations of learning activities as a form of feedback. The team.sPace study focused on the visualisation of the quantities of learner activities in an information sharing environment. The ReScope study analysed a visualisation of personal concepts. The present study seeks for the common aspects of the two visualisations in order to infer initial design principles from these results. For this purpose the results of the studies were analysed if and to what extent they help to answer the overarching research questions.

Regarding the first question on the effects of visualisations and aggregators and their arrangement, the team.sPace study indicated that the same underlying sensor information influenced the participants' perception of the collaborative activities, and that more complex design principles for activity indicators are required. The insights of this study were partially used for designing ReScope, which reflected the context dimensions "concept" and "process". The findings of the second study were in line with the expectations according to the framework.

The second question concerns data collection and aggregation for providing meaningful information to self-directed learners. The analysis of team.sPace suggests that contextual factors are not relevant at the sensor level, because both visualisations were based on the same activity data. The differences were at the level of aggregation and of visualisation. This is in line with the analysis of the tagging habits that suggests only differences between active and passive tagging, but not between the participation level of the participants.

The final question on the relevant contextual information cannot be answered by the two studies, because the studies did not cover all contextual dimensions and factors that are suggested by the theory on situated learning. Despite the limitations and the differences of the studies, two design principles can be identified for contextual learning support. These principles can be named as *perspective* and *contrast*. Although both principles were identified in the context of information visualisation, they refer to educational and cognitive aspects of the personal learning processes as it is described in the following sections.

6.1 The design principles and the architecture for context-aware systems

This section puts the two design principles in relation to the system architecture for context aware systems. This helps to make more targeted design decisions while implementing tools for supporting self-directed learning.

The perspective principle can be reflected at the level of aggregators and controllers. In the first design study the concept of perspective was only implicitly reflected in the design, but the findings suggest that the perspective principle correspondents to aggregators and to their arrangement in an adaptation strategy. This insight has been applied in the design of the ReScope tag cloud of the second design study.

The contrast principle can be associated to indicators and the arrangement of aggregators in an adaptation strategy. This suggests two types of contrast. The first type can be described as visual contrast. This type reflects the presentation mode of the information at the level of an indicator and allows a learner to compare and relate different aspects of contextual information. The second type can be described as information contrast. This contrast type is related to the arrangement of aggregators and depends on the type of information that is provided by the contrasting aggregators.

While contrast at the level of indicators mainly addresses the visualisation of information in terms of usability, is contrast at the level of controllers focused on the arrangement of potentially meaningful information. At this level the aspects of perspective and contrast are tightly coupled in the design decisions. The designs studies covered in this paper were based on the contextual framework that was developed from the literature on situated learning. This framework defines relations between contextual dimensions and context factors and has been used a guide for defining, selecting, and arranging aggregators for supporting self-directed learning processes.

6.2 Design principles in team.sPace

team.sPace can be considered as a group information system, because it displays the resources of a group portal. Therefore, the general perspective of team.sPace is a community perspective, i.e., the participants use the system to share information with their peers.

The activity visualisations provide two different perspectives of learner activity. The action counter visualisation indicates provides a personal perspective on the participant's actions. The visualisation shows only a participant's actions. In this

visualisation the contrast principle is not reflected, because it relies only on a single aggregator. Thus it can be considered to show a personal perspective.

The performance chart provides a community perspective on the participants' actions, because it shows the personal actions as a percentage of the actions that were performed by the most active participant and in relation to the group's average activities. This information contrasts the personal information and contextualises it to the group. To achieve this contrast, the chart relies on two aggregators. One to compute the personal performance and one to compute the group's average performance.

The different perception of the two indicators in the team.sPace study can now be explained as following. The performance chart was more engaging for the contributing participants of the group, because it fitted to the perspective of their use of the system while contrasting their effort with the group's average. The personal perspective of the activity counter could not meet the perspective of the other participant's primary use of team.sPace: the personal perspective on the actions did not provide meaningful information for the participation in the group.

6.3 Design principles in ReScope

ReScope provides a tag cloud that shows the global and the recent use of tags of a participant with the delicious.com social bookmarking system. The system offers no form of collaboration with other users. Therefore, the primary perspective of using ReScope is considered as personal.

The tag cloud combines two concepts in the visualisation. The first concept is the general focus of the tags that are related to web resources that the participant has assigned to the personal bookmarks. The second concept is the process, in which the temporal interests of the user change. These concepts encoded differently into the tag cloud. The general focus of a tag is encoded in the font size of a tag. The temporal interests are encoded by the colour intensity of a tag in the tag cloud. This co-presence of information contrasts the temporal interests with the general interests of a participant.

At the level of the arrangement of the aggregators, the information shown in ReScope is selected from two information feeds that offer pre-aggregations of a delicious user. These feeds are provided through the delicious.com feed API. As both perspectives use similar information, namely the number of tags over a defined time period, they can be used to highlight different aspects of tagging web resources to the participants.

The reflections that were documented by the participants of the ReScope study suggest that contrasting two types of personal information supported the participants for reflecting their tagging behaviour.

7 Conclusions

The findings that are presented in this paper provide only initial answers on the three research questions. However, the findings show despite all their limitations that the concepts of situated learning can be applied for developing technological support for self-directed learners. By focussing at the context factors that were identified for

situated and collaborative learning it is possible to provide targeted solutions for supporting self-directed learning. This implies that situated learning can be technologically supported beyond providing and arranging tools for learners and communities. With the help of indicators it becomes possible to provide PLEs as tools for self-directed learning. .

Activity indicators can provide valuable information that allows learners to create meaningful relations between their actions, their knowledge, and their environment. This meta-analysis of our previous studies on the application of indicators for supporting self-directed and incidental learning extracted two design principles that appear to be relevant if visualisations of user activities should provide feedback on learning processes in loosely structured environments. The first principle is perspective. This principle suggests that this type of feedback has to provide a meaningful view on past actions that integrates the prime context of the learner. The second principle is contrast. This principle suggests that information is perceived as relevant if it is presented in relation to similar information of a different perspective. In this paper illustrates how these principles were applied in two different systems that integrate Web2.0 services for collaborative and for personal use.

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