Visualisation of interaction footprints for engagement and motivation in online communities – results of first interviews

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Abstract: Contextualised and ubiquitous learning are relatively new research areas that combine the latest developments in ubiquitous and context aware computing with educational approaches in order to provide structure to more situated and context aware learning. The majority of activities in contextualised and ubiquitous learning focus on mobile scenarios, in order to identify the relation between educational paradigms and new classes of mobile applications and devices. However, the meaning of context aware learner support is not limited to mobile learning scenarios by default. The educational paradigms of situated learning and communities of practice highlight these needs for informal learning and for workplace learning. In this paper we analyse learner participation as a contextual dimension of adapting graphical indicators for engaging and motivating learners in participating and contributing to an open community of practice. For this purpose we analyse six interviews with selected participants of that community. We compared the reactions of the learners who were provided different indicators during their interactions with an online system. The results of these interviews illustrate the impact of small variations in the aggregation and visualisation of interaction footprints on the engagement of learners at different contribution levels.

Keywords: Awareness Support, Context-aware Systems, Evaluation, Informal Learning, Learner Support

1 Introduction

Contextualised and ubiquitous learning are relatively new research areas that combine the latest developments in ubiquitous and context aware computing with educational approaches in order to provide structure to more situated and context aware learning. The majority of activities in contextualised and ubiquitous learning focus on mobile scenarios, in order to identify the relation between educational paradigms and new classes of mobile applications and devices (Naismith, Lonsdale, Vavoula, & Sharples, 2004). However, the meaning of context aware learner support is not limited to mobile learning scenarios by default. The educational paradigms of situated learning and communities of practice (Lave &

Wenger, 1991) highlight the need for contextualisation of informal learning, particularly where the learning activities are related to the workplace or to other social environments. In these scenarios learning processes are often unstructured, unguided, and sometimes even unintended.

In this paper we analyse learner participation as a contextual dimension of adapting graphical indicators for engaging and motivating learners in participating and contributing to an open community of practice. The purpose of the research underlying this paper is to identify variables and conditions for selecting and adapting visualisations of "interaction footprints" (Wexelblat & Maes, 1999) in order to facilitate context sensitive learner support in unstructured learning environments. An unstructured learning environment is best described as an environment in which learners interact at different expertise and activity levels where participants have changing or implicit roles, and interact without guidance of an expert or a pre-defined curricular structure.

For this purpose, we conduced an experimental study, using the team.sPace environment (Glahn, Specht, & Koper, 2007) and interviewed selected learners who participated in this study. In this paper we analyse the results of these interviews. However, before we proceed with the data, the following sections provide an overview of the related research, the underlying research question, a more detailed description of the team.sPace environment, and the hypothesises that were investigated by this study.

2 Background of research

Wexelblat & Maes (1999) showed that interaction footprints of users support peers to navigate through unknown information. Interaction footprints are traces that are left by a user while interacting with a system. In most cases these interaction footprints are stored in server log-files and remain unused. Wexelblat & Maes' idea of utilizing interaction footprints to support navigation and the identification of relevant information, is underlying most approaches to social recommendation in technologically enhanced learning (Drachsler, Hummel, & Koper, in press). Dron, Boyne, & Mitchell (2001) utilize this approach for a system that supports explorative learning on the web, which comes closest to the use of interaction footprints in informal learning. Recently, Frazan & Brusilovsky (2004) captured and analysed different kinds of interaction footprints in order to improve the quality of adaptive annotations.

Dey & Abowd (1999) define context aware systems, as systems that "provide relevant information or services to the user, where the relevancy

depends on the user's task". Zimmermann, Specht, & Lorenz (2005) indicate that interaction footprints are important sources for contextual information. Newer findings of Zimmermann, Lorenz, & Oppermann (2007) identified five dimensions of context information, among which time and activity refer to processes as contexts of users.

Butler & Winne (1995) reported that environmental responses on actions are crucial to learners for controlling and structuring their learning process, and introduced a system model of the cognitive processes that are crucial to self-regulated learning. According to the authors, the result of these cognitive processes is the learner's decision whether and how to proceed with their interactions with an environment. This implies that the responses on the learners' activities affect the quality, pace, and duration of their future learning activities, which includes also the option of dropping out.

Although the model proposed by Butler & Winne model looks as a simple input-output model at the first sight, it is an evolutionary model, because the model includes the self-regulating capabilities of the learners to the responses given by an environment. The actions and reactions of the learners are aligned to their past experiences and are integrated into their "knowledge". This implies that the learning process is not a constant process, in which each response has always the same effect. Instead, the learner's experiences are evolving, which affects the interpretation of external responses on a learner's actions. This is a well known effect in workplace related competence development (Wenger 1999; Elkjær, Høyrup, & Pedersen, 2007; Chisholm, Spannring, & Mitterhofer, 2007), and has been referenced by Knut Illeris (2003) with the expressive article title "learning changes throughout life".

Erickson & Kellogg (2003) provide some examples of supportive visualisations of interaction footprints with regard to social information about online spaces, such as discussion forums. Such "social proxies" – as the authors call these visualisations – are "minimalist graphical representations that portray socially salient aspects of an online situation" (Erickson & Kellog, 2003). These indicators present the status of, and the relations between participants in an online environment. While doing so, social proxies are not limited to a general view of these parameters, but also visualises the social dynamics relative to a social space. One effect of presenting social information without recommending learning activities or navigational behaviour has been reported as "waylay". "Waylay refers to the practice in which a user monitors the Cookie [a social proxy] for signs of another person's activity […], and then initiate contact." (Erickson & Kellogg, 2003) The concept of waylay is different to what has been described as stigmergy (Dron, Boyne, & Mitchell, 2001). While stigmergy refers to pathways of activities that emerge through collaborative

activities, waylay refers to virtual landmarks which are used by users to structure and plan their social activities themselves.

While "waylay" is related to a user's observations of public (virtual) spaces, Kreijns (2004) identified a similar effect related to group awareness indicators on distributed activities of peer users. The author calls this effect "social affordance". Social affordance has been observed with indicators that display the activity of other users within an online environment. Different to social proxies, these indicators provide informations about the activities of users relative to the activities of their peers, without providing information how these activities are interrelated.

Social affordance refers to information that stimulates acitivities that are aligned to the social practice within a collaborative environment. According to the author social affordances create and depend on two relationships between the learner and the environment: the "reciprocal relationship" and the "perception-action coupling". The reciprocal relationship is based on the social intentions of a learner and on how meaningful an environment can respond to these intentions. The perception-action coupling refers to the connection of the learners' recognitions of their environment, including the actions that they will perform in accordance to it (Kreijns, 2004).

Previous research (Glahn, Specht, & Koper, 2008) has shown that most visualisations of interaction footprints are limited to a single approach for data aggregation and visualisation. Another finding of this research was that these approaches have been evaluated in structured learning environments. However, given to Butler & Winne's model using static approaches of learner support in competence development appears not sufficient with for the learners' cognitive self-regulation processes, and to the learners' changing needs for information on their overall learning progress.

In order to facilitate more adaptive responses based on interaction footprints an architecture for adaptive collecting, aggregating, and visualising interaction footprints has been proposed (Glahn, Specht, & Koper, 2007). This architecture defines a structured way of defining, retrieving and visualising attention meta-data, which are based on aggregations of interaction footprints. Adaptation strategies can get defined on top of the generated data. For testing the effectiveness of this architecture for supporting engagement and reflection in informal learning an the initial scenario has been described. For this scenario several "good" contextual boundaries have been assumed for adapting the visualisation of interaction footprints. However, these assumptions lacked of empirical evidence regrading their effectiveness to structure and to support informal learning processes.

3 Question for Research

Motivating this research were the empirical shortcomings of the solution which has been proposed by Glahn, Specht, & Koper (2007). The authors discuss support for learners in informal learning on two levels, namely "engagement and motivation" and "reflection". Our research focussed on "engagement and motivation", by addressing the question, *whether the reception of the visualisation of interaction footprints changes the engagement and motivation in participating in group activities for learners at different participation levels.*

With regard to this research question, we were particularly interested if the effects of "waylay" (Erickson & Kellogg, 2003) and "social affordance" (Kreijns, 2004) are dependent to the participation level of a learner in an online community.

4 team.sPace

In order to get a first idea about structuring and adapting visualisations of interaction footprints to the users' style of contributing to the community, we used a modified version of the originally described team.sPace system (Glahn, Specht, & Koper, 2007). Using this version of team.sPace we conducted a three month experiment within our department. Figure 1 shows a typical view of team.sPace for an authenticated user.

team.sPace is an information portal for online communities of practice, which jointly form a larger learning network (Jochems & Koper, 2005). Each community in team.sPace is founded around the topics and the interests of their users. The participation in team.sPace is open, which means that users can register and set their personal information as they would do, if they were using another social software on the web.

Taking a more technical perspective, team.sPace fetches news feeds about web-log entries and social bookmarks of its registered users, it aggregates the information provided by the feeds, and presents this information to the members of a group. In addition to this basic function, team.sPace embeds features for stimulating the users engagement in the community, and facilitates reflection on the user's contribution and reading interests. These additional features take up the concepts of social proximity (Erickson, 2007) and group awareness (Kreijns, 2004; Kreijns & Kirschner, 2002).

Glahn, Specht, & Koper (2007) described an adaptation strategy for indicators about interaction footprints. This adaptation strategy adapts the aggregation and visualisation of low-level interaction data to a user's contribution level. With regard to engagement and motivation two

visualisations of interaction footprints were integrated into the system. These visualisation are sequenced by the adaptation strategy in a way that a team.sPace user would see only one of these indicators at a time.

For testing the contextual conditions for the adaptation strategy we removed the initially implemented adaptation strategy and made each indicator available only to one user group. The assignment of an indicator was static, which means that the users received only one visualisation of their interaction footprints for the entire period of the experiment. Apart from the different indicators about their interaction activity all participants used the team.sPace in the same way. The modified version of team.sPace has two indicators.

Figure 1 Screenshot of team.sPace with authenticated user

The first indicator is an activity counter. This activity counter displays the interaction footprints of a participant. Each action of a participant is counted; and all actions have the same impact on the visualisation. The activity is visualised in a horizontal raster bar-chart (see Fig 2). This bar-chart does not grow homogeneously with each activity. Instead, the user has to "earn" each field of the raster with a pre-defined number of actions. With an increasing number of earned fields more actions are required to earn a new field.

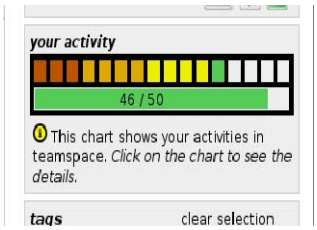

Figure 2 activity counter in use

The second indicator extends the first indicator in three ways. Firstly, it values the different activities with a factor that is multiplied to the user's activity points for that activity. This means that the activities have a different impact on the activity of the participant. For example a blog entry is worth ten points while selecting a link is worth a single point, only. Secondly, the activity is not displayed in absolute terms, but relative to the activity of the most active user in the group. Finally, the indicator integrates a second bar, which charts the same information for the average participant of the community. The performance indicator is shown in Fig. 3.

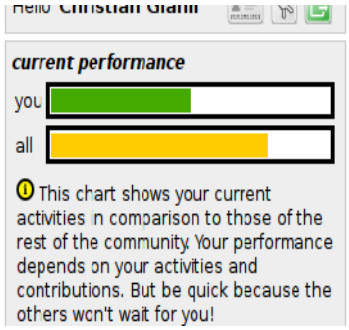

Figure 3 the performance indicator in action.

Both indicators reflect only the actions within the last seven days. This forbids users to pile-up actions and keeping their status while being inactive. Furthermore, if the participants click on an indicator it will open a small overlay window, that shows the sources and the values in detail which were visualised by the indicator.

5 Hypothesises

With the experiment we intended to analyse the relation of visualising interaction footprints and user engagement and motivation at different stages of the learning process. According to our previous considerations

on self-regulated learning and context adaptation in the background section of this article, we formulated four hypothesises.

1. The activity counter is stimulating engagement for non-contributing users.
2. The activity counter will be ignored by contributing users after an initial phase of using team.sPace.
3. The performance indicator is stimulating engagement and motivation in participating in the environment for contributing users.
4. The performance indicator is distracting for non-contributing users.

The four hypothesises refer to the adaptation pattern, in which non-contributing team.sPace users receive activity indicators, and contributing users receive a performance indicator. Regarding the interviews we expected to receive answers that will provide a first idea if these hypothesises are supported by the representing users for each subgroup of the experimental group. This provides insights on the quality of the selected adaptation pattern.

6 Method

In order to come as close to the learning processes within a community of practice, the experiment has been conducted with the participation of selected researchers of a research department at the Open University of the Netherlands. The participants have been selected according to the similarity of their research topics, while previously these persons were not collaborating intensively with each other.

30 persons were contacted for participating in the experiment. They were asked to participate voluntarily and use team.sPace for a period of three months, in which they should set team.sPace as the start up page of their web browser. From the persons who have been asked for volunteering, 15 finally registered themselves to team.sPace and participated in the experiment. Each participant has been automatically assigned to use one of the two indicators, in order to guarantee that about the same number of users were assigned to both indicators. For the experiment nine users were assigned to the performance indicator and seven were assigned to the activity indicator.

Once the participants have registered they were asked to fill a questionnaire about their previous experiences with social software, about the way how they use web2.0 tools in their research activities, and about their group awareness. Additionally, to the questionnaire, all interaction

footprints of all requests have been stored in a database. These interaction footprints include the reading activities, the contribution activities, information retrieval activities of on-site browsing, and interaction detail retrieval activities. Finally, six users who represent specific user types have been selected for interviews in which they report in a free form about their experiences in using the system.

In this paper we report report about the first responses from the interviews. We selected six participants, who were interviewed individually in a face to face meeting. We interviewed three participants for each indicator, where one has been fully contributing to the community, one has been contributing only social bookmarks, and one did not contribute at all. We selected our interview partners according to the frequency of using the system, according to their user type, and according to the treatment that they have received. All interviews were semi-structured and were between 20 and 30 minutes. During this time frame we asked the participants to reflect about their use of team.sPace, about the parts of the system which they liked and disliked, and about their impression of the indicator that was available to them.

7 Results

As already mentioned, 15 participants contributed to the experiment. Five participants registered their research web-log in team.sPace, nine participants registered their nick name for delicious, and six participants can be considered as team.sPace readers, as they did contribute neither via web-logs nor via social bookmarks. All participants who were contributing their web-log, were also contributing delicious bookmarks. 13 participants filled the questionnaire, of whom nine stated to have prior experiences with various kinds of social software. The contributors have posted 1303 bookmarks and 108 web-log entries over the three month period of the experiment. During this period the team.sPace portal has been visited 926 times by authenticated users. The participants followed 331 times a link to a contribution and used 389 times a tag of the tag could to filter the information for a specific topic. During the experiment the participants checked 137 times the detailed information of their indicator.

This data indicates that team.sPace has been mainly used as a group awareness tool that provides a quick overview about the dynamics in the group. This impression has been confirmed by all participants we interviewed.

All interview partners replied on the first question about their general use of the system, that they frequently visited the portal, but they admitted that quickly after the beginning of the experiment they stopped using it as

a start-up page of their browser. Instead they visited the page when it suited their working schedule. In these cases they checked what the other participants were bookmarking or posting on their web-logs. Nevertheless, they followed links only, if its abstract was interesting.

The interviewed participants reported that they liked the content organisation of team.sPace for providing a quick overview of the topics the other group members were dealing with. The participants that were contributing social bookmarks and web-logs reported that through team.sPace they started to estimate features of the external systems that they used prior to the experiment, already. An example of such experiences was the ability to comment bookmarks in del.icio.us. Although adding notes and comments to bookarks is an integral feature of all bookmarking systems, it is rarely used by default. However, in a group context, the comments can be used to highlight special features of a URL that is relevant to the community. Another example was provided by two participants: they reported that they learned about the value of social bookmarking when it is used within a group. Realising this was mentioned as a surprise by one participant, because the participant used del.icio.us for some time before the launch of team.sPace.

With regard to the general use of the system, the participants who received the performance indicator were also focussing more consciously on the quality and quantity of the contributions of the other users. One contributing participant was complaining about link “stealing”, when others bookmarked links that were previously posted by that participant on team.sPace and – from the perspective of that participant – received performance points for that. The other contributing participant was contributing only social bookmarks and mentioned that the “bloggers” were “ruining” the performance by posting three or four postings almost simultaneously.

For the participants from the activity indicator group none of the interviewed contributors mentioned their recognition of such dynamics on team.sPace during the interviews. However, the participants of this group reflected more about their experiences with the usability and the interface functions of team.sPace.

All interviewed participants reported that they disliked the content browsing feature of team.sPace. They found the collaborative tag cloud little helpful to find the contents they were looking for. One participant reported that it was not able to find a contribution via the tag cloud, although the participant remembered that the entry was on team.sPace. The participants would have also liked to see the tags that were related to an entry. Furthermore, the participants were requesting a peer information feature, that provides a link to the user's blog, a link to the bookmarks on del.icio.us, user based content filtering, or the tags that were used by

another participant. Finally, the authentication procedure was not well received by the participants.

With regard to the question, how the participants experienced the indicators that were displayed to them, the two groups responded very differently. Those participants who were seeing the activity indicator, responded that they checked their indicator at the beginning of the experiment, and used it for finding out how the indicator responds to which interactions. Two within this group even "admitted" that they "tricked" the system to gain more points. However, for all three participants of this group the indicator lost its attraction after a while and the all three participants used team.sPace mainly as a working group news portal, and in case of the contributors they contributed at their own pace. The participant, who was contributing bookmarks and web-log entries, stated that the indicator was "irrelevant" for visiting the portal.

The user group who received the performance indicator answered differently. At the beginning of the experiment all three participants reported similar to the first group that they were playing around with the system in order to get familiar with the impact of their activities on the indicator. Because the underlying aggregator weights the different activities, it is more challenging for non-contributors to keep their performance up with the group. The non-contributing participant of this group reported this experience as "frustrating", because the "bloggers" and "taggers" get all the points while the own activity chart hardly takes off. In this particular case this frustration lead to a counter reaction: the participant created a new del.icio.us account and posted a few links in order to see their impact on the performance. After the short reaction phase the participant did not post any new links, but dropped out of the experiment.

The contributing participants perceived the performance indicator more positive and connected it to the challenge of keeping up and out perform the community. In the interview both participants even asked if the indicator was displaying random information, because sometimes they estimated their performance better than what the indicator displayed. Nevertheless, both participants managed to become superior to the group and gain a maximum peek on the chart. According to the participants, this was very satisfying. The participant who contributed only bookmarks via del.icio.us made this even a personal objective, which was reported as "pretty challenging" because of the random "waves" of web-log postings. Both participants reported that they followed the dynamics of the contributions carefully, as they related them to their impact on the performance indicator. Besides this generally positive connotation, both participants also mentioned that while they were "under performing" the indicator was a constant reminder. The participant who contributed both,

bookmarks and web-log entries, reported "high pressure" in those cases when the personal performance chart was dropping and there was no time for new contributions due to other obligations.

8 Discussion

Results from interviews always provide weak evidence for validating hypothesises. However, they can provide first impressions about what we can expect from quantitative data. In case of team.sPace the interviews unveiled differences about the emotional affect of the indicators regarding the engagement and motivation in contributing to the portal.

While both groups were initially attracted by understanding the relation between their activities and the visualisation of the indicator, after the initial phase of using the system the participants from the activity counter group were less engaged on an emotional level. Instead their responses focussed more on the general functions and usability of team.sPace. Particularly the responses from the contributing participants support hypothesis 2, whereas hypothesis 1 has weak support, because the participant did not respond negatively on the effect of the indicator but gave no clear statements regarding a positive effect, either.

The responses of participants from the performance indicator group had a greater emphasis on recognising the group dynamics with a strong relation to valuing mechanisms of their activities related to team.sPace. With that regard, the responses of the contributing participants support hypothesis 3. Although the non-contributing participant acted proactive as a reaction to the "bad performance" shown by the indicator, the reported "frustration" supports hypothesis 4.

That the hypothesis 3 and hypothesis 4 are supported has an important implication for the concept of social affordance. The participants at different contribution levels responded differently regarding the indicator that displayed additional social information to the learner. Therefore, it appears that the social affordance of this indicator varies in different contexts. In our specific case, we identified from the reactions of our interview partners that contributing to a community is a contextual variable that affects a participant's way of interpreting social activity information and reacting to it.

9 Conclusions and further researchs

In this paper we analysed six interviews with selected participants of an experiment of using the visualisation of interaction footprints engagement

and participation in an online portal. The goal of the study was to analyse learner participation as a contextual dimension for adapting graphical indicators for engaging and motivating learners in participating and contributing to an open communities on the web. For this purpose we interviewed users who participated in a quasi-experiment in which two user groups received different visualisations about their interaction activity.

We compared the reactions of learners who used an activity counter that visualises only the interaction footprints of the learner who sees the indicator, with those of learners who used a performance indicator that visualises the same information in relation to the rest of the community. Of course, the results of interviews do not provide "hard" evidence of contextual variables, but they illustrate the impact of small variations in the aggregation and visualisation of interaction footprints on the engagement of learners at different contribution levels.

The important finding of this qualitative study is that the concept of social affordance (Kreijns, 2004) appears to be context dependent. However, further analysis of the available data and more focused research into that direction is therefore required for providing more evidence on these preliminary findings.

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References

Butler, D. L., & Winne, P. H. (1995). "Feedback and self-regulated learning: a theoretical synthesis". *Review of Educational Research, 65*(3), 245-281.

Chisholm, L.A., Spannring, R., & Mitterhofer, H. (2007). "Competence development as workplace learning in German-speaking Europe". In: L.A. Chisolm, H. Fennes, & R. Spannring (Eds.) *Competence development as workplace learning*. Innsbruck University Press, Innsbruck, 99-120.

Dey, A. K., & Abowd, G. D. (2000). "Towards a Better Understanding of Context and Context-Awareness". Paper presented at the CHI 2000

Workshop on the What, Who, Where, When, and How of Context-Awareness.

Drachsler, H., Hummel, H., Koper, R. (in press). "Personal recommender systems for learners in lifelong learning: requirements, techniques and model". *International Journal of Learning Technology*.

Dron, J., Boyne, C., & Mitchell, R. (2001). "Footpaths in the the stuff swamp". Paper presented at the World Conferences on the WWW and Internet, Orlando, Florida, United States.

Elkær, B., Høyrup, S., & Pedersen, K.L.(2007). "Contemporary nordic research on workplace learning". In L.A. Chisolm, H. Fennes, & R. Spannring (Eds) *Competence development as workplace learning*. Innsbruck University Press, Innsbruck, 19-42.

Erickson, T. (2007). "'Social' systems: designing digital systems that support social intelligence". AI & Society, available at DOI - 10.1007/s00146-007-0140-3.

Erickson, T., & Kellogg, W.A. (2003). "Social Translucence: Using Minimalist Visualizations of Social Activity to Support Collective Interaction". In. Köök, K. et al. (Eds.). *Designing information Spaces: the Social Navigation Approach.*, London: Springer, 17-41.

Farzan, R., Brusilovsky, P. (2005). "Social navigation support in e-learning: what are the real footprints?" In: Mobasher, B., Anand, S.S. (eds.) Intelligent Techniques for Web Personalisation (ITWP'05), Edinburgh, Scotland.

Glahn, C., Specht, M., & Koper, R. (2007). "Smart Indicators on Learning Interactions". In E. Duval, R. Klamma, & M. Wolpers (Eds), Creating New Learning Experiences on a Global Scale: LNCS 4753. Second European Conference on Technology Enhanced Learning, EC-TEL 2007; Berlin, Heidelberg: Springer, 56-70.

Glahn, C., Specht, M., Koper, R. (2008). "Smart indicators to support the learning interaction cycle". *International Journal of Continuing Engineering Education and Life-Long Learning* (IJCEELL), 18(1), 98-117.

Illeris, K. (2003). "Learning changes throughout life". *Lifelong Learning in Europe, 8*(1), 51-60.

Jochems, W. & Koper, R. (2005). "Lifelong learning in a network". Paper presented at Open and Distance Learning Association of Australia Conference: 17th, 2005, Adelaide.

Kreijns, K. (2004). *Socialble CSCL Environments; Social Affordances, Sociability, and Social Presence.* Doctoral thesis, Open University of the Netherlands, Heerlen, The Netherlands.

Kreijns, K., & Kirschner, P. A. (2002). "Group Awareness Widgets for Enhancing Social Interaction in Computer-supported Collaborative Learning Environments: Design and Implementation". Paper presented at the 32nd ASEE/IEEE Frontiers in Education Conference, Boston, MA.

Lave, J. and Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature Review in Mobile Technologies and Learning* (Literature Review No. 11): University of Birmingham.

Wenger, E. (1999). *Communities of practice: learning, meaning, and identity*. Camebridge, New York: Camebridge University Press.

Wexelblat, A. & Maes, P. (1999). "Footprints: History-rich Tools for Information Foraging". *Proc. SIGCHI conference on Human factors in computing systems: the CHI is the limit*, ACM, 1999, pp. 270-277.

Zimmermann, A., Lorenz, A. & Oppermann, R. (2007). "An Operational Definition of Context". In *Modeling and Using Context*. LNCS 4635. 6th International and Interdisciplinary Conference, CONTEXT 2007, Roskilde, Denmark, August 20-24, 2007. Berlin, Heidelberg: Springer, 558-571.

Zimmermann, A., Specht, M., & Lorenz, A. (2005). "Personalisation and context management". *User Modeling and User-Adapted Interaction, 15*(3-4), 275-302.