Focus and Exploration in Contextual Relevance

Mamdouh Eljueidi[1], Chiara Rossitto[2], Ilaria Canova Calori[1]

[1]Department of Computer and Information Science
Norwegian University of Science and Technology
Trondheim, Norway
{mamdouh, canovaca}@idi.ntnu.no

[2]Department of Computer and Systems Sciences
Stockholm University
Stockholm, Sweden
chiara@dsv.su.se

Abstract—**The ubiquity of learning resources can be both empowering and challenging for mobile learners. The development in context-aware computing presents promising tools that support learning activities and offer learning opportunities, through providing the learners with relevant resources. By drawing on an existing model of contextual relevance, this article provides empirical examples of how contextual relevance can emerge and unfold throughout a mobile learning activity. It draws attention to how learning outside the classroom can facilitate engagement with the physical environment and its exploration, thus determining a thin balance between being on track, and triggering new discussions. The findings show that interaction between the ongoing activity and the environment assists focus, whereas exploration is promoted by interaction between the background and past experiences of the learner and the environment. Finally, ontological, interpretational and presentational issues are presented as design challenges.**

Keywords-contextual relevance; mobile learning; ubiquitous learning.

I. INTRODUCTION

Development in ubiquitous computing facilitates enhanced learning experiences. It envisions technology-rich environments that along with personalized handheld devices can offer learners different forms of contextualized and situated learning activities. However, context-aware services and applications for mobile learning have to cope with various challenges. First, learners are overloaded with information that demands significant efforts in managing it and selecting the relevant. It is a task that mobile learning technology has to do effectively [1], otherwise could increases the cognitive load of the learner and consequently obstruct the learning process. Secondly, learning objectives develop through the course of interaction with the environment [2]. Finally, people do not pursue fixed goals [3]. On the contrary, they might change and define them in the course of a certain activity in response to sensory information. On a technological level, this represents the challenge of designing mobile learning applications that enable exploration while reflecting relevant pedagogical objectives. This means that context-aware services and applications have to support ongoing activities, while allowing learners the possibility to engage in serendipitous encounters. Context-awareness is not to be seen merely as tool for adaptation to changing context, but as a resource for the learning activity. Similarly, change in context is not to be seen as a problem to overcome, but as an emerging opportunity to seize.

In an earlier work [4], we have approached the question of context by adopting the interactional view of context by Dourish [5] and by drawing on the theory of relevance by Sperber and Wilson [3]. A model of contextual relevance was developed where relevance is the distinct factor of what is context and what is not. It takes into account the past of the learner and the dynamics of the present to handle context as it unfolds. This paper elaborates on the model by applying it to an exploratory field study. In so doing, we seek to provide concrete examples of what aspects of a mobile learning activity determine a change in relevance, that is to say, a change in the relevant context.

The work presented is concerned with the concept of City-wide Collaborative Learning (CwCL), where learning is conceived as emerging from exploring authentic settings, interacting with peers and experts, and from serendipitous encounters providing opportunities for exploration and interaction [6].

The following section presents different perspectives on using context for content provision. It shows examples of research efforts that use context for content delivery and others that see context itself as the knowledge or a type of knowledge. The third section introduces the model of contextual relevance developed within previous research [4]. The fourth section introduces two field trips that are later used in section five to elaborate our understanding of change in relevance. Section six introduces a number of design challenges emerging from the framework suggested.

II. RELATED WORK

In a survey on context-aware pervasive learning environments, Laine and Joy [7] observe three possible roles that the physical environment can play in pervasive learning: (i) context for learning if the system uses features in the environment to adapt accordingly; (ii) content for learning when information from the environment are used as learning resources; (iii) system resources as triggers for system events.

The combined use of technology in the environment and in the personal handheld devices of the learner extends the capabilities of these devices and gives learners access to both physical and virtual local resources, whether these resources are used as content for the learning activity itself or

supporting the process of learning. A main concern in technology-enhanced learning is providing learners with these learning resources they need from the overwhelming resources that surround them in prospective technology-rich environments.

Context-awareness sub-system (CAS) [8] is a module in the MOBIlearn project that aims to provide individuals with learning resources and services. CAS presents users with a filtered set of relevant learning content that they can choose from. They do that by intelligent matching between content metadata and context metadata. Bomsdorf [9] approaches this by introducing the notion of Plasticity of digital learning spaces that goes beyond UI adaptation into the selection and/or adaptation of learning material (content), services and tools, by evaluating adaption rules against the learner's profile and resource meta-data. Wolpers [10] attempts to solve a similar problem and his approach is to individualize and personalize learning based on Contextualized Attention Metadata (CAM) that facilitates the learning process, and provide learners with the tools they need, rather than those presumed by designers. CAM information is a second order profile represented in a user model that provides a holistic view on the user and his activities, which is used in observing attention in order to filter and prioritize incoming information. This is based on the assumption that information provision is a main mechanism of learning, in parallel with the learning process. Cooltown project [11] on the other hand, proposes integrating virtual reality and physical locality by dynamically generating web places. A web place is a representation of a physical place based on the context of the user; location, time, user ID, and the capability of the device being used, people physically in the place. This web place will present users with a list of available services for the environment as they move through it, and they can select and execute services.

These are some examples of research efforts that explore the problem of providing relevant content and services to the learner based on context, often by meta-data matching. There is an underlying assumption in these attempts that delineates context elements, and learning objects and services. This brings about the question of what context is. In connection with this, there is the issue of relevance, which turns out to be meta-data matching in many cases, in consequence of the aforementioned assumption.

Context and relevance has been widely explored in artificial intelligence (AI) and decision-support systems. It is a perspective on context that should not be simply overlooked. One example of this research is the efforts by Öztürk and Aamodt [12] to exploit context for case-based reasoning in medical diagnosis. They adopt an epistemological view of context as a knowledge type. They distinguish between two types of context, external context and internal context. The former represents the situation, represented by the environment and the target case, which they see as static. The latter represents the state of the mind that captures goals, interest, expectations, and other information needed by the reasoner and that emerges as it is solves the problem. Together they form contextual knowledge, which they separate from the core domain knowledge. The authors see relevance as an indicator of the quality of the solution produced, while focus as relating to the efficiency of problem solving. Focus of attention is promoted by the internal context to subsets of domain knowledge, case base, and external knowledge.

Ekbia and Maguitman [13] criticizes this tradition of logic as it fails to account for context and relevance. In formal logic, explicit representation of knowledge is needed. Consequently, the result will be to either codify too many or tool little facts as the spectrum of relevant facts is unrestrained. The authors refer to the theory of relevance by Sperber and Wilson [3] as the one that successfully account for context and relevance in the domain of speech communication. They see pragmatic relevance as the alternative, and that is more concerned with selecting the search space, which is taken for granted in AI, rather than the search process itself. The authors of another research efforts develop a knowledge-intensive model of context for ambient intelligence using a socio-technical perspective. They use activity theory to develop a context model with personal perspective; a subjective view on context, and propose taxonomy of context as personal, task, social, spatio-temporal, and environmental contexts [14]. They agree that whether knowledge is contextual or not is determined by context, and thus they do not see context as a distinct type of knowledge. The authors in [15] differentiate, however, between relevant and irrelevant contextual knowledge. Based on the current focus of task, a part of the knowledge is proceduralized for use in decision-making, while the other part of knowledge is external.

As mentioned earlier, we adopt the interactional view of context by Dourish [5]; it is not whether something is context or not, rather if it is contextually relevant or not. Hence, contextuality is a relational property. Thus, we do not distinguish between the subject matter and context. Context is what proves to be relevant to the learner right here and right now, whether a feature of the environment, learning object, learning service, or other peer learners.

III.   MODEL OF CONTEXTUAL RELEVANCE

A proper conceptualization of context is required in order to understand how technology accounts for context and to guide the design of context-aware mobile systems. Attempts to conceptualize context and understand its role in CwCL requires an understanding of the human process of learning and acquiring knowledge, an understanding of how humans sets their learning goals, and when and why they change them, and accordingly an understanding of context can develop. We addressed this problem of context in CwCL by developing a model [4] that attempts to support ongoing learning activities while allowing seizing emerging opportunities. It adopts Dourish's view of context as an interactional problem where context is a relational property. Objects and information are contextual only if relevant to the activity or interaction. It also draws on the relevance theory [3] of how people communicate and understand each other in context to assess relevance. Relevance is dynamic and varies continuously as user needs, goals, and intentions vary over time. The model defines two roles of context in CwCL:

1) Supporting ongoing activities: enhancing the activity by providing resources that help learners to better complete the task. Opportunities could emerge while interacting with the social and physical space that can serve the ongoing activity. The learner has then to either ignore this encounter and pursues the task, or interrupt the task and pursue the encounter. A third option can be valid in some cases where learners can hold the encounter or revisit it some other time.

2) Supporting opportunistic interaction: exploiting serendipitous encounters to provide the learner with opportunities for interaction that are relevant to an ongoing activity, history of interaction, the learner profile and interests, or such. There is a need to consider an interaction level that can hold a view of the learner's ongoing activity, history, profile, interests, etc. to provide the learner with resources that match their needs at the right time. There is a tension between keeping the focus and exploiting emerging opportunities that maximizes the benefit of being in a specific place at a particular time.

The model also defines three interconnected constructs of context: 1) long-term memory that includes the learner's profile, interaction history, previous experiences, learning ontologies, etc. It is by taking this existing knowledge of the individual learner that proper information provision can occur to support a proper cognitive process of learning, something that is often overlooked [10]. Long-term memory evolves through time as the learner gains more knowledge and undertake new experiences. It reflects the development of the learner. 2) Short-term memory: related to the current ongoing task, which represent attention in human cognition. It includes the information about the participants of the activity, the topic and different encounters of the ongoing activity. Short-term memory provides conditions to filter the relevant from the incoming information. It reflects the dynamicity of the learning activity. 3) Perception (the world): information that can be captured by the sensory of the user, or a software agent in the handheld device on behalf of the user. Perception reflects the uncertainty that is present in new environments, where resources are not pre-defined and are not stable throughout the activity. It also reflects the here and now.

IV. USER STUDY

The empirical material we draw on was collected during a qualitative study carried out at an international school in Norway. In order to understand what contextual elements become relevant during mobile learning activities, we decided to approach the school setting without intervening. This means that, before providing the class with any mobile technology to be used in the context of their daily activities, we sought to understand how such activities naturally unfold.

During the study we followed a fourth grade class to two different field trips: one to an open-air folk museum, and the other to a cathedral and its museum. Children were between 9 and 10 years old; 20 pupils were present during both trips. Data were collected mainly through qualitative methods: observations, audio-recordings and note-takings, as well as a follow-up interview with the teacher. Both excursions lasted about four hours from the moment we arrived at the school,

to when we departed after the visits were over. We focused on understanding what contextual elements are relevant during a field trip, and how they facilitate learning, besides other research question: (i) how a learning experience unfolds before, during and after a field trip; (ii) the connections between class and outdoors activities and two subsequent visits; (iii) resources and artifacts used.

Understanding the field trips in the context of the other educational activities was instrumental to our goal to develop mobile devices and services to enhance learning outside the classroom.

When the study was carried out, the class was working on a six-week unit of inquiry about Norway. The first trip was concerned with the relationships between Norway's climate and its culture, and the class visited the local open-air folk museum, where traditional buildings (e.g., farms, churches and houses from different periods) have been moved from all over the country. The second trip focused instead on the cultural influence of religion in the Norwegian society. This excursion included two separate visits: one to the museum where original sculptures from the cathedral and archaeological exhibitions are displayed, and the other to the cathedral itself. Each visit was led by a different guide. The two trips offered two interesting settings to understand the situatedness of a learning experience, and to begin exploring what contextual aspects contribute to a meaningful engagement with the physical environment. In this paper we focus on two scenarios extracted from the field trips.

A. Scenarios

The first scenario draws on data collected during the visit to the open-air museum, when the guide took the class on a tour through different types of houses that had been built in Norway throughout the centuries [16]. As mentioned above, the main goal of this visit was to help pupils gain a direct experience of how climate had shaped the way houses were constructed and used. Nevertheless, being inside one of the farmhouses, and discussing the objects available in there (i.e. a loom, pottery and other utensils) was also an occasion to contextualize societal and cultural aspects. For instance, a pupil's question about a pendulum watch present in the room, opened up a whole discussion about Norwegian immigration to the US in the beginning of the 1920s and 1930s. The fact that the pendulum had been brought from the US was, thus, an occasion to tackle economical issues on Norwegian society, and to concretely explain why famine had forced people to migrate to another country. This was also an occasion to compare different types of economies, and how Norway evolved from an agriculture-based economy to an industrial one.

The second scenario draws on data collected during the visit to the cathedral and its museum. The experience of this field trip was very different from the previous one. While narratives about physical artifacts and different parts of a farm enabled the guide and the teacher to anchor historical and cultural aspects, the visit at the cathedral was characterized by the use of various abstract and technical concepts (e.g., a typical gothic arch, comparisons between Greek and Northern mythology, etc.) the children had

difficulties to understand. A significant episode was the visit to the area of the museum that used to be the mint. In similarity with the previous field trip, the exploration of the physical place shifted the discussion towards economical and societal issues. This time, however, the children had problems understanding the relationships between coining money and inflation. These difficulties were determined by the lack of a background knowledge the kids could relate to in order to understand what was being said.

V. CHANGE IN RELEVANCE

According to the interactional view of context, contextuality is dynamic and constantly in renegotiation.

A. Contextualizing a Learning Activity

The field trips we observed had been prepared in advance, as a part of a broader educational unit about Norway. In this sense, the trips were complementary to more traditional lessons that took place in the classroom. Although these indoors and outdoors learning moments are generally regarded as formal and informal respectively, the trips were perceived by the pupils as part of traditional schoolwork. They were aware of the role of the teachers, and that the trips constituted a moment for listening and understanding.

While the guides at both field trips were aware of the themes the class was working on (climate and Christianity in Norway), no specific topics had been negotiated with the teacher. The pupils contributed in shaping the discussions with their questions that were triggered by a combination of the encounters in the surroundings, the dialogue with the guide, their previous experiences and knowledge. For instance, inside one of the farms at the folk museum, the guide showed the children an old, wooden piece, and she explained it was carved as a proposal gift as a way to manifest serious intentions of getting married to a woman. Observing other artifacts, such as spoons and porridge balls gave the opportunity to anchor food habits, how food was produced and stored, and nutritional problems people might have. These moments were also important as they allowed the children to reflect on their current situation, and to understand the past by means of comparing it to their daily lives. While objects played a major role in situating the learning experience, they also triggered interesting discussions that had not been planned by the guide or the teacher. While inside the farmhouse, one of the pupils asked about a pendulum clock, and since it had been brought from US, the question raised a discussion about famine and Norwegian immigration to US in the beginning of the 1920s and 1930s.

These examples show that physical artifacts present in the physical environment contributed to the development of the ongoing learning activity, as well as triggering serendipitous exploration. Thus, the main activity, which is exploring historical aspects of Norway, is an umbrella for many trajectories of learning. Serendipitous interactions with the environment triggered questions that, in turn, contributed to further develop the discussions.

Another focus of analysis that presents a bridge towards design is the constructs of context in CwCL. Interaction of the pupils and the physical and social surroundings is contextualized in one of three interconnected constructs of context (see Figure 1):
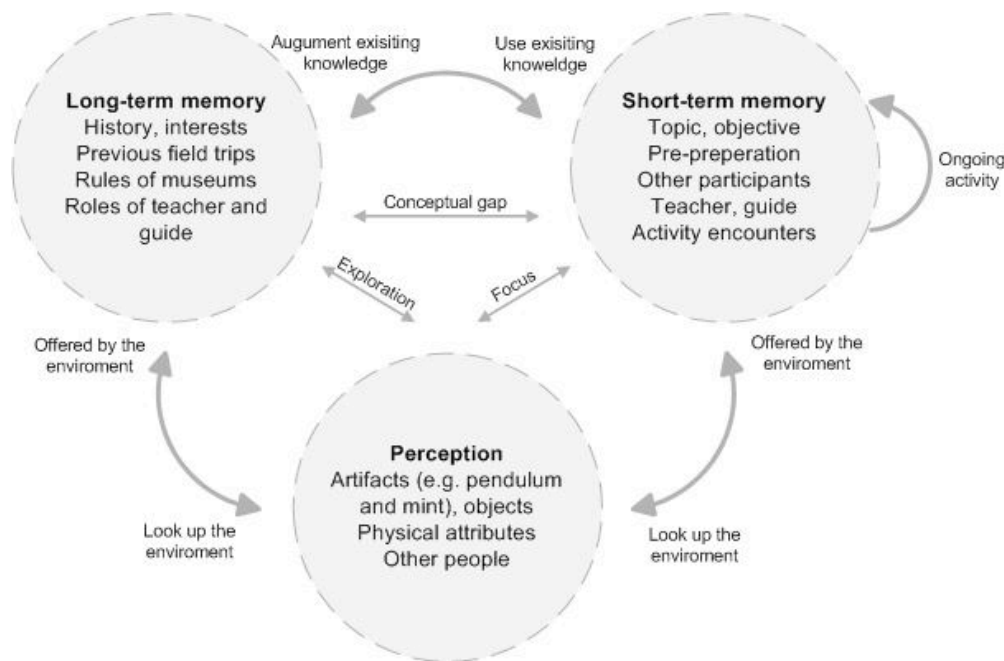

Figure 1. The constructs of context and their interaction –the environment pro-actively offers resources that support the ongoing activity (focus), and that promotes exploration based on the background of the learner, or reversely, requested by learner or by his agent on his behalf.

Long-term memory: the pupils have a base of assumptions about field trips. They are used to them as a part of their schoolwork, and they also have previous experiences with the rules in museums. They are aware of the roles of the teacher and the guide. Each individual pupil has his own background, interests and experiences.

Short-term memory: the kids are aware of the topic of the field trip; they prepared in class, and they were instructed at the museum. They keep track of the different events within the activity, where they started and how they progressed. This includes the main objective and the one that the teacher tries to keep focus on. It is however selective, unlike the background of pupils. This construct includes also the teacher, guide, and other classmates.

Perception: the different artifacts and ambience that situate the learning experience and offers sensory information that promotes physical exploration.

It is interaction amongst the three constructs that enable and drive the ongoing activity, which is represented by the second construct and supported by the other two constructs. Additionally, these three constructs play other roles, as conflicting states of mind in a dialectical interaction, where each attempts to occupy the attention of the learner. The long-term memory construct represents life-long learning, and the perception construct represents the tendency to exploit serendipitous encounters. The main activity (as represented by short-term memory) is what the teacher and the guide attempt to draw its boundaries. They make use of artifacts in the surroundings to teach pupils about pieces of history. This ongoing activity was supported by the perception (the local environment) and the assumed previous knowledge and interests of the pupils. Pupils on the other hand, with the main activity in mind, they set different boundaries of the activity based on their real previous knowledge and their own perception of the environment, which sometimes crossed the boundary that is intended by the guide or the teacher.

B. Understanding Relevance and Change

From the discussion above and drawing on concepts presented in the related work section, there are two notions that can be associated with contextual relevance (see Figure 1):

1) Focus: focus of attention on the ongoing activity is promoted by interaction between the ongoing activity (short-term memory) and the environment (the perception).

2) Exploration: exploration is triggered by the interaction between the background (long-term memory) and environment. Exploration is relevance through time and ensembles, and it promotes capturing emergent, unplanned events.

A third interaction that can be acquired from the data is the externalization and internalization processes that take place between the long- and short-term memories, in case of a conceptual gap where the intellectual level of an individual is not met. All these interactions can be both ways, i.e. initiated by any of the two constructs.

Note that the three constructs of context are being augmented and changed as the interaction progresses. The long-term memory will have the long-lasting effect. This includes updated interest for example that can be taken as a retrospective trigger for a future visit.

Change in relevance can be triggered by change in the individual constructs. For example by change in the physical and social environment that takes place through action or new phenomena in the environment, availability of new objects, change of the user location, or change in the accessibility of peers, etc. Change can also be triggered by development through change in the user intentions and goals or through changes in the conception of knowledge, foci of attention, interests, etc.

VI. TOWARDS DESIGN

Provision of contextual features to learners as they are needed is met with several design challenges. First, an ontological representation challenge: how and to what extent to represent entities in the world. Three constructs of context handles different perspectives of context and represent different aspects of the interaction; the individual, the activity, and the environment. This can require different heterogeneous solutions to model each of them. Secondly, an interpretational challenges for inferring relevance and reasoning on contextual features. All opportunities are possible distractions, and proper processing of information is essential. Also, it can be important here to take into consideration the recommendation of Greenberg [17] of being conservative in taking action based on context. Although pupils were triggering new topics, the teacher and the guide had tendency to stick to the pre-defined topic. This proposes an important question, which is how groups of learners are going to behave in the absence of a teacher and guide. Who will decide what path to go, what is relevant and what is not. This is of significant importance as there is no central unit to represent shared activities. This is a question that does not pop up in case of individual tasks. The intention is not replace teachers with technology. The teacher played an important role in keeping the kids focused. However one might think of scenarios when pupils are left alone for a limited time to attend to some assignment. The third
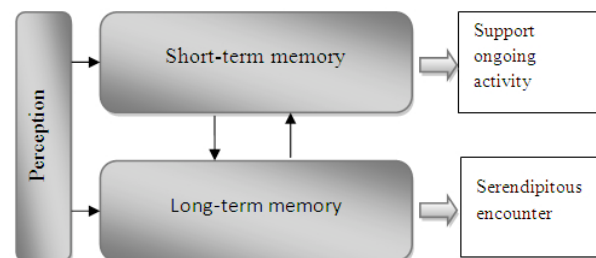

Figure 2. Short-term memory: represented by an activity model and reflects the dynamicity of the ongoing interaction in pursuing a specific objective and promotes focus. Long-term memory: represented by a user model and reflects the background of the user, his strategic goals, and development, and triggers exploration.

challenge is presentational: how to present context to the learner. In a user study with technology in the project Ambient Wood [18], researchers found out that notifications by the environment to the handheld devices were sometimes going unnoticed. This is either because learners were too busy to respond or because they did not observe the incoming notification. We propose that the level of intrusivity should vary based on the role that the notification serves. In other words, opportunistic encounters should be less intrusive than those meant to enhance the ongoing interaction (focus versus exploration), and based on the direction of trigger initiation (environment versus individual). Modals of communication could also differ based on that.

Figure 2 shows a conceptual architecture of a context-aware system that promotes focus and exploration.

VII. CONCLUSION AND FUTURE WORK

This paper discussed provision of learning resources to learners as the interaction unfolds in view of a user study that elaborated on the model of contextual relevance. It pointed out the different sources of interaction across the different constructs of context, where the environment offers an opportunity space that claims the attention of the learner and promotes exploration, while the goal-orientedness of the ongoing activity promotes the focus of attention. Both exploration and focus are for the purpose of maximizing the benefit of being here and now. It introduced then some design challenges: ontological, interpretational, and presentational.

Developing a selection mechanism that infers relevance is the main concern and the task at hand for further progress in this research effort.

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REFERENCES

[1] M. Koole, "A Model for Framing Mobile Learning," in Mobile Learning: Transforming the Delivery of Education and Training, M. Ally, Ed.: Athabasca University Press, 2009, pp. 25-47.

[2] G. Vavoula and M. Sharples, "Challenges in evaluating mobile learning," in The 7th World Conference on m-Learning 2008, pp. 1-8.

[3] D. Sperber and D. Wilson, Relevance: communication and cognition. Oxford: Blackwell, 1995.

[4] M. Eljueidi, "Contextual Relevance in City-wide Collaborative Learning," in IADIS International Conference Mobile Learning 2011 Avila, Spain: IADIS Press, 2011, pp. 119-126.

[5] P. Dourish, "What we talk about when we talk about context," Personal Ubiquitous Comput., vol. 8, pp. 19-30, 2004.

[6] I. Canova Calori and M. Divitini, "Reflections on the role of technology in city-wide collaborative learning," International Journal of Interactive Mobile Technologies (iJIM), vol. 3, pp. 33-39, 2009.

[7] T. H. Laine and M. Joy, "Survey on Context-Aware Pervasive Learning Environments," International Journal of Interactive Mobile Technologies (iJIM), vol. 3, pp. 192-199, 2009.

[8] P. Lonsdale, C. Baber, M. Sharples, and T. N. Arvanitis, "A context awareness architecture for facilitating mobile learning," in Learning with Mobile Devices: Research and Development, J. Attewell and C. Savill-Smith, Eds. London, UK: Learning and Skills Development Agency, 2004, pp. 79-85.

[9] B. Bomsdorf, "Adaptation of Learning Spaces: Supporting Ubiquitous Learning in Higher Distance Education," in Mobile Computing and Ambient Intelligence: The Challenge of Multimedia: Dagstuhl Seminar Proceedings, 2005, pp. 1-13.

[10] M. Wolpers, "Contextualized attention metadata in learning environments," UPGRADE: The European Journal for the Informatics Professional, vol. 9, pp. 57-61, 2008.

[11] D. Caswell and P. Debaty, "Creating Web Representations for Places," in Proceedings of the 2nd international symposium on Handheld and Ubiquitous Computing Bristol, UK: Springer-Verlag, 2000, pp. 114-126.

[12] P. Öztürk and A. Aamodt, "A context model for knowledge-intensive case-based reasoning," Int. J. Hum.-Comput. Stud., vol. 48, pp. 331-355, 1998.

[13] H. R. Ekbia and A. G. Maguitman, "Context and Relevance: A Pragmatic Approach," in Third International and Interdisciplinary Conference on Modeling and Using Context Dundee, UK: Springer-Verlag, 2001, pp. 156-169.

[14] A. Kofod-Petersen and J. Cassens, "Using Activity Theory to model context awareness," in Modeling and Retrieval of Context. vol. 3946 of LNCS, T. Roth-Berghofer, S. Schulz, and D. Leake, Eds. Edinburgh: Springer Verlag, 2006, pp. 1-17.

[15] P. Brézillon and J.-C. Pomerol, "Contextual knowledge sharing and cooperation in intelligent assistant systems," Le Travail Humain, pp. 223-246, 1999.

[16] C. Rossitto, I. C. Calori, and M. Divitini, "Exploring a City: Understanding Situated Learning Experiences," in IADIS International Conference Mobile Learning 2011 Avila, Spain: IADIS Press, 2011, pp. 227-232.

[17] S. Greenberg, "Context as a dynamic construct," Hum.-Comput. Interact., vol. 16, pp. 257-268, 2001.

[18] Y. Rogers, S. Price, G. Fitzpatrick, R. Fleck, E. Harris, H. Smith, C. Randell, H. Muller, C. O'Malley, D. Stanton, M. Thompson, and M. Weal, "Ambient wood: designing new forms of digital augmentation for learning outdoors," in Proceedings of the 2004 conference on Interaction design and children: building a community Maryland: ACM, 2004, pp. 3-10.