Ambient Learning Displays: lecture series and results from a participatory design study

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ABSTRACT
Emerging from pervasive and mobile technologies, ambient displays present information and media in the periphery of the user. Thereby the displays situated and interacting in the close proximity are an addition to existing personal interfaces in the foreground, while the user attention can always move from one to the other and back. Especially the ability to deliver contextualised and personalised information in authentic situations fosters ambient displays as an instrument for learning. However the actual design of ambient displays for learning proves to be difficult, as the technical implementations as well as the underlying instructional principles are still immature. The paper presents the main constituents of a lecture series on the use of ambient displays for learning and a first participatory design study conducted during two consecutive lecture sessions. The results show a variety of usable ambient display types, possible learning scenarios, and specific design proposals towards ambient learning displays.

Author Keywords
Ambient Learning Displays; Participatory Design; Conceptual Framework; Ubiquitous Learning Support; Situational Awareness; Feedback; Lecture

INTRODUCTION

Definition
Following linguistic definitions the compound term ambient displays characterises appliances present in the close proximity of mainly visually solicited receivers. Thereby the adjective ambient is defined as "relating to the immediate surroundings of something" or "relating to or denoting advertising that makes use of sites or objects other than the established media" (Oxford Dictionaries, 2010), while the noun display is among others defined as "a collection of objects arranged for public viewing", but also as "an electronic device for the visual presentation of data or images" (Oxford Dictionaries, 2010). Wisneski et al. (1998) finally introduced ambient displays as "new approach to interfacing people with online digital information". Inspired by Weiser's vision of ubiquitous computing (Weiser, 1993) the "information is moved off the screen into the physical environment, manifesting itself as subtle changes in form, movement, sound, colour, smell, temperature, or light" (Wisneski et al., 1998). Instead of demanding attention the approach exploits the human peripheral perception capabilities.

Theoretical Approaches
Following Wisneski's view (Wisneski et al., 1998) on ambient displays awareness can be deduced as a main instructional characteristic of ambient displays. To grasp the application possibilities of ambient displays in learning contexts this concept needs to be further exploited and theoretical approaches like situational awareness (Endsley, 2000) need to be considered for an instructional perspective. Endsley defines situational awareness as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future". Following this definition the author presents three levels of situational awareness that can be used for classification, namely perception, comprehension, and projection. Especially on the higher levels of situational awareness the type and characteristic of feedback given by the ambient displays plays an essential role for their effectiveness, impact, and behavioural change capabilities and thus is another important instructional characteristic that can be deduced. In that sense also the concept of providing (instructional) feedback (Mory, 2004) needs to be incorporated.

Conceptual Design
In a first attempt to facilitate the design of ambient displays for learning the authors examined relevant research findings, models, design dimensions, and taxonomies based on the assumption that the information presented in context needs to be acquired, channelled, delivered, and framed in the learning process. The result is a conceptual framework that provisionally defines ambient learning displays (Börner, Kalz, & Specht, 2011) and consists of parts dedicated to acquisition, channelling, delivery, and framing.

An example of an ambient display that also fits well into the conceptual design framework, is the "Elements" prototype by (Gyllensward, Gustafsson, & Bang, 2006). The authors designed the alternative radiator information display

consisting of 35 light bulbs to visualise the invisible energy consumption of radiators at home. The display utilises solely internal and external temperature sensors as source of information.

METHOD

The presented participatory design study has been conducted during two consecutive lecture sessions on the use of ambient displays for learning with the goal to inform and ease the design process. The participants were asked to fill out a short participatory survey during the sessions. The survey consisted of three parts dedicated to ambient learning display (a) types, (b) scenarios, and (c) designs as well as some demographic information (i.e. age, background, gender).

The participants were asked to fill in each part separately within one minute after an introduction on each subject matter and an explanation on what is expected from them. The parts were introduced following the presented foundation underpinning the research on ambient displays for learning, i.e. definition of the ambient display concept, theoretical approaches, conceptual design framework, as well as examples.

RESULTS

In total 28 participants (22 male, 6 female) in the age between 21 and 44 filled out the survey. Thereby most participants have had a computer science background, with only some exceptions coming from health care, psychology, or technology-enhanced learning. The reported results are structured into the three parts (a) types, (b) scenarios, and (c) designs. Table 1 lists the main results per survey part.

Ambient Display Types

When asked to come up with usable ambient display types, some participants described in some form or another existing displays already used to convey information, e.g.

"flat screens in the lobby", "whiteboard in room", "digital screens, placed on walls or tables", "display embedded in the mensa", "commercial board", "Billboard like large display", "wall clock".

Others described enhanced versions of technical appliances, so far not necessarily used to convey additional information beyond their intended purpose, e.g.

"Speed Control", "Smart Pen", "automatic dough analyser within bowl", "electric toothbrush, but smarter", "mp3 player", "weights display", "power outlet", "mobile device", "bus stop", "desk".

Although all the mentioned appliances pragmatically fulfil their specific functionality, they apparently lack a certain degree of feedback on the respective user actions performed with the appliances. The remaining participants then described new display types utilising mainly visual appliances, such as glass, windows, or mirrors, e.g.

"view from my living-room window", " window, mirror in the bathroom", "Display on glass", "windows in cars".

Learning Scenarios

Besides listing ambient display types, the participants were also asked to describe potential learning scenarios where these displays could be used. Following the theoretical approaches introduced and explained, the results can be grouped according to the main objective of increasing awareness, providing feedback, or learning.

Awareness

The scenario described most by the participants is the provision of "information within context related to the current situation/needs". Other scenarios described exemplify this concept, e.g.

"every time I enter our work building […] show some nice ti[t]bits of information [e.g.] next agenda item", "Display giving information about buildings around you", "remind me of appointments and the possibility of being late/on time", "display/project material (e.g. slides, documents) at anytime and everywhere", "showing weather in the street", "nutrition of food", "random historical info/trivia about [the city]".

Obviously the ambient displays in these scenarios are mainly used to support users by increasing awareness of contextual information. The only exceptions described by participants are a "display [that] shows different landscapes" and a display that visualises "how many cyclist[s] passed the bridge". These displays also increase the user's awareness, but do not provide comparable support.

Feedback

Beyond increasing awareness the participants also assigned scenarios where ambient displays provide feedback, e.g.

"the display warns you by blinking", "feedback about: maturity, resistance, fluidity, time to go", "present countdown", "sport training […] calculating all necessary data: tempo, blood pressure, speed, time etc.", "the energy consumption of an outlet", "running speed", "driving information".

Mostly this provision facilitates immediate reflection on the performed action. Additionally the provided feedback might also include suggestions on how to adapt or improve respective behaviour, e.g.

"identify […] hand writing and offer some suggestions to improve his/her hand writing", "[how] to brush teeth", "what to do next", "current weight […] recommendations what to eat, should you make more exercises".

Notably all these scenarios describe a reoccurring cycle know as the feedback loop, whereas the performed action immediately feeds back to the assessment and reflection on the action and so forth.

Learning

Finally the other scenarios described by the participants depict the acquisition of factual, conceptual, or procedural knowledge and thus learning in various forms partly building up on awareness and feedback, e.g.

"learning of languages […] helping to improve pronunciation or build-up vocabulary", "preparing for TOEFL exam […] help me memorize the vocabulary", "display facts – ask for facts".

Two interesting scenarios mentioned here are the comparison of "the sun's relative position" and learning "how to prevent 'bad air'" in a room. Both have the potential to encourage an ambient display design with a real added value compared to other learning designs or technologies.

Survey part		Results
Ambient Learning Display	Type	(Embedded) display screens, billboards Technical appliances of daily use (e.g. toothbrush, clock) Glass, windows, or mirror displays
	Scenario	Awareness of contextual information (e.g. agenda, nutrition, weather) Feedback on user action (e.g. sports, cooking) Learning languages or psychomotor skills
	Design	Addressing various senses (focus on visuals and lighting) Non-disruptive (e.g. gesture-based interaction if needed)

Table 1. Survey parts and respective results

Ambient Learning Display Designs

Incorporating the previously described ambient display types and learning scenarios, the participants showed differences in terms of innovation, creativity, and accuracy when describing the actual design of their ambient learning display. Ranging from pragmatic descriptions, e.g. "[…] light up picture of device", up to more detailed implementations, e.g.

"display map of teeth on mirror, showing the […] teeth that need more attention […] in combination with motion sensors shows child on mirror where he/she is brushing [or needs to brush]", "display shows different landscapes, places, cities and plays also the respective sounds (+smell); content can be selected and played randomly or customised on daytime or mood".

Others were clearly inspired by recent technical developments or announcements, although extending the functionality or using them in a learning context e.g.

"Could be implemented as a screen or goggles providing information on objects that a person sees. The objects could be named, translated into the language of a user. Additionally a sound system could be used to teach the user […] proper pronunciation".

Interestingly most of the designs described by the participants address various senses, while the main focus remained on visual aspects like lighting, e.g.

"Tells you by light, sound and maybe smell that you should open the window [e.g.] very soft music, light turns red", "They don't necessarily want to take a look at the screen – just feel it […] Beside traditional displaying the weather, it can use strong light for sunny weather, blow air for windy, sound for oncoming storm, etc.".

One participant goes even further, including not only senses but also sensor functionality, following the idea of utilising existing embedded displays, and even drafting possible interaction patterns, i.e.

"can push the words I currently recite on different ambient displays around my room […] When I reach it, it will show the meaning of the word. When I do some gesture, it means I already recited this word, so the display will show me a new word".

DISCUSSION AND CONCLUSIONS

The results presented show a variety of usable ambient display types, possible learning scenarios, and specific design proposals towards ambient learning displays. Regarding ambient display types and their design the results complement a recent literature review on the design and evaluation of ambient displays (Börner, Kalz, & Specht, Submitted). Beside depicting characteristics and classifying prototypical designs, the review also sheds light on the actual use of the covered ambient displays, their application context and addressed domains as well as the type of studies conducted, including the used methodologies and evaluation approaches to measure their effectiveness and impact. The participants of the participatory design study described different ambient display types, whereas the majority either utilised embedded display screens or billboards, converted existing technical appliances of daily use, or harnessed mainly visual appliances like glass, windows, or mirrors.

Furthermore the presented results depicting learning scenarios and ambient learning display designs complement another recently submitted literature review, that analyses work in the research field of ambient display with a focus on the use of such displays for situational awareness, feedback and learning (Börner, Kalz, & Specht, In Press). The review results expose that the explicit use of ambient displays for learning is not a prominent research topic, although implicitly ambient displays are already used to support learning activities fostering situational awareness by exploiting feedback. Congruently the participants had difficulties describing concrete learning scenarios and respective ambient learning display design. Mainly, the scenarios described by the participants had the objective to increase awareness of contextual information, provide feedback on user action, or support the learning of languages or psychomotor skills.

Overall the lecture series and the associated participatory design study help to ease the design process of ambient learning displays and inform the further research on this technological concept with great potential for learning. Thereby the focus is on the development of new display types addressing the whole range of senses as well as the utilisation of existing already embedded displays. Regarding learning scenarios theoretical concepts like (situational) awareness and feedback need to be incorporated to shape learning experiences so far not touched upon by ambient displays. The actual design of ambient learning displays remains challenging but not impossible.

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