

# Goal-Awareness and Goal-Adaptive Information Presentation to Support Collaborative Learning in Informal Settings.

*Eva Mayr*

Virtual Ph.D. Program  
Applied Cognitive and Media Psychology, University of Tuebingen

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## **Abstract:**

*Adaptive systems (e.g., PDA or hypermedia) provide an opportunity to present customized information on museum exhibits according to visitors' goals. Personalized information presentation allows visitors to explore an exhibition at their own choice but to get information adjusted to their interests. Thereby, elaboration of information in informal settings and knowledge acquisition can be enhanced. Two experimental studies are conducted in this dissertation to confirm the expected learning benefit of adaptive information presentation in museums. Visitor dyads explore a museum (study 1: virtual, study 2: laboratory exhibition) and get information adapted to their shared interests. Impact on information selection, conversation and learning outcomes is studied. Implications for design of adaptive technologies are discussed.*

## **1 Dissertation Goals**

Implementation of mobile devices in museums and other informal learning settings is increasing. An important goal of this dissertation is to design an innovative media application enhancing knowledge acquisition in informal settings. For this purpose, the strength of research in educational technologies, museum studies, and particularly cognitive psychology are combined to achieve new insights into this interdisciplinary research field.

Based on an analysis of characteristics of informal settings, the lack of goal orientation was identified as central characteristic influencing information processing in museums. An adaptive media application was designed that approaches this problem in two ways: First, it asks visitor dyads for their shared goals and thereby makes them aware. Second, it adapts exhibit information to these shared interests. The impact of this media application on visitor behaviour, information selection, conversation, and learning is studied. Results of this research project can give further insight for design of future media applications.

## **2 Background of the Project**

### **2.1 Introduction**

This dissertation is conducted within the wider context of a research project on learning in the museum with new technologies (Deutsches Museum, Munich; Institute for Science Education, Kiel; Knowledge Media Research Center, Tuebingen) funded by the "Pact for research and innovation" of the German Federal Ministry of Education and Research. In this project the learning potentials of media applications in museums are explored. Theories and research methods from cognitive psychology, educational science, and museum studies are

combined to study the impact of educational technologies on visitor behaviour and experience in museums.

## 2.2 Special Characteristics of Informal Learning

Definitions of informal learning by its location (school / university vs. museum / family) are widely criticised (e.g. Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Malcolm, Hodkinson, & Colley, 2003; Martin, 2004). Despite the efforts of different research groups, a common definition of informal learning is still missing (Colley, Hodkinson, & Malcolm, 2004; Malcolm et al., 2003). In an extensive review of informal learning literature Malcolm and her colleagues suggest to define a setting by multiple characteristics (process, location, purpose, and content of learning; see table 1). Similarly, Bransford and his colleagues (2006, p. 220f.) suggest to look at the structuring properties of a context. These characteristics of formality or informality are not new (compare for example Scribner, & Cole, 1973, on differences in content), but were regarded as dichotomous, whereas Malcolm and her colleagues define them as continuous.

**Table 1.** Informality / formality of a learning setting (Colley, et al., 2004; Malcolm et al., 2003, p. 315f.)

<i>more informal</i>		<i>more formal</i>
incidental to everyday activity	<i>process</i>	structured tasks
learner-controlled		teacher-controlled
peer / colleague as pedagogue		teacher as pedagogue
no assessment		summative assessment
workplace, community, family	<i>location &amp; setting</i>	educational institutions
no time restriction		timely restricted
no predetermined learning objectives		predetermined learning objectives
no external certification		external certification
activity without learning focus	<i>purpose</i>	learning as focus of activity
learner determined and initiated		learning to meet external criteria
development of something new	<i>content</i>	acquisition of expert knowledge
everyday practice		propositional knowledge
incidental outcomes		specified outcomes

If the characterisation by Malcolm and her colleagues (2003) is applied to a museum setting the *processes* of learning are rather informal: There are no predefined tasks, but everyday activities (talking, reading, exploring ...). Depending on exhibition design learners can control their learning activities more or less (e.g., fixed audio tour). Additionally, as a museum visit is a social event in most cases (cp. Black, 2005) learning is mediated by the social environment (Packer, & Ballantyne, 2005). The *location* is a leisure setting, but with an educational mission. Visitors can visit a museum without time restriction, but at the same time mental resources for acquisition of new knowledge decrease with time ("museum fatigue", Bitgood, 2002; Evans, 1995; Petrelli, Not, & Zanchanaro, 1999). Learning objectives may exist in exhibition designers' minds, but remain implicit and not apparent for the visitor. Still the *purpose* of the visit could be learning, but many visitors come without learning intentions (50 – 56 %; Black, 2005; Packer, 2006). More frequent agendas for a museum visit are social outings or leisure experiences. The *content* of the acquired knowledge cannot be controlled by the museum; it is incidental and even misconceptions may result. Other outcomes are often regarded as more important: Increased interest, opinion formation, or conversations are also widely used indicators of learning in museums.

An important characteristic of the museum setting addressed in this dissertation is the missing goal-orientation for the visit: Every second visitor does not come to a museum to learn; only half of the remaining visitors have a specific learning goal in mind (Black, 2005; Packer, 2006). This influences how information is processed.

### **2.3 Goal-oriented information processing**

Setting specific goals is an important part of cognitive processing (cp. ACT-R, Anderson et al., 2004): Goals heavily influence information search, information selection, information evaluation, and information elaboration. It could be shown that goal-oriented learners take more time on goal-relevant information, elaborate more on that information, and have better learning outcomes (e.g., in the domain of hypertext learning, Schnotz, & Zink, 1997; Zumbach, & Reimann, 2002). Goals are also important in collaborative learning processes: For example conversation is mostly goal-directed with respect to content, referencing, and joint actions (cp. Clark, & Brennan, 1991; Clark, Schreuder, & Buttrick, 1983; Russell, & Schober, 1999).

An analysis by Boekaerts and Minnaert (1999) shows that goals may be even more important in informal settings than in formal ones: Goals have to be set by the learner himself, he has to select appropriate information, and has to process it with respect to these goals (individually and during conversation with others). Falk, Moussouri, and Coulson (1998) could indeed show that a focused visiting strategy enhances mastery of learning content in a museum.

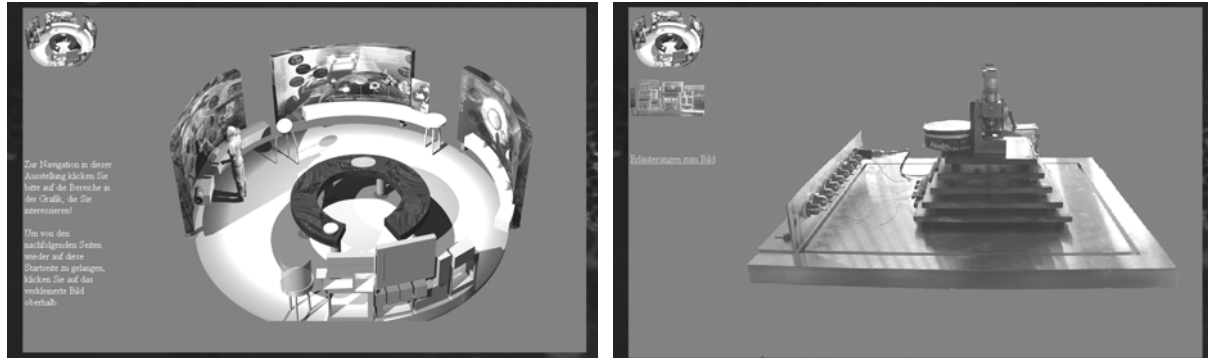
But cognitive resources for information processing are limited, especially in informal learning. According to Salomon (1984) in leisure settings information is processed with less mental effort. This seems to hold also for museums as visitor's attention is very limited (Serrell, 1997). The average visitor spends 19 minutes in an exhibition and 51 % of the visitors look at less than half the objects available.

The social situation can reduce the amount of mental resources needed by providing structure: Agendas are often implicitly inherited in an existing visitor group (e.g., school classes: learning intention, parent-child groups: exploration intention) and shared interests guide their visit. Other visitors serve as model for information selection (social navigation; Höök, 2003) and for elaboration on information in conversations (conversational elaboration; Leinhardt, Crowley, & Knutson, 2003). But not only other visitors, also the museum can provide structure and guide visitors in a way that reduces the amount of mental resources needed to process the presented information. Following this rationale, principles for object organisation (Falk, 1997) and label design (Bitgood, 2000) are broadly used in museums. But these actions do not serve all visitor groups in the same way: Visitors substantially differ, for example in their interests, prior knowledge, and time resources. Adaptive media applications can come up to these personal needs.

### **2.4 Adaptive Media in Museums**

There are different possibilities to adapt information in a museum setting to visitors' needs: In a virtual museum an adaptive hypermedia system can be implemented (e.g., Brusilovsky, 2003). In the real museum electronic labels at the exhibit itself (e.g., with visitor RFID tags like in His, & Fait, 2005) or information presented via mobile systems can be adapted (e.g., Petrelli, & Not, 2005). Adaptation can be based on visitor input (explicit input, e.g., Teo, 2005) or on visiting behaviour (implicit input, e.g., Not, Petrelli, Stock, Strapparava, & Zancanaro, 1997). Either recommendations (e.g., adaptive visiting tour; Bright et al., 2005; Teo, 2005) can be adapted or content (e.g., adaptive exhibit descriptions; Oberlander, Mellish, O'Donnell, & Knott, 1997).

In this dissertation a virtual museum (graphical adaptive hypertext, see figure 1) is compared to a parallel real exhibition (adaptive PDAs). According to Frost (2002) digital objects as well as authentic, real ones have their own unique characteristics and therefore cannot be compared with each other. At the moment no studies exist that directly compare interaction with digital objects in the context of virtual museums (Schweibenz, 2004) and interaction with the same authentic objects within a real museum exhibition.



**Figure 1.** Screenshots of the virtual museum “NanoDialogue”

In both cases visitors will not receive recommendations for specific objects but personalized exhibition content: Descriptions of each exhibit will be adapted to visitors’ shared interests to allow user-control in exhibit selection (Boekaerts, & Minnaert, 1999; Jameson, & Schwarzkopf, 2002) and enable satisfaction of situational interest (Loewenstein, 1994). This adaptation will be based on explicit user input: Active selection of shared goals produces awareness of these shared interests in a dyad. Conscious goals (cp. Austin, & Vancouver, 1996) are more powerful as they are available in working memory, therefore structure processing of information with respect to this goal (cp. Anderson et al., 2004), and guide conversation (cp. Russell, & Schober, 1999). In a control condition there may be realised some form of implicit input for adaptation.

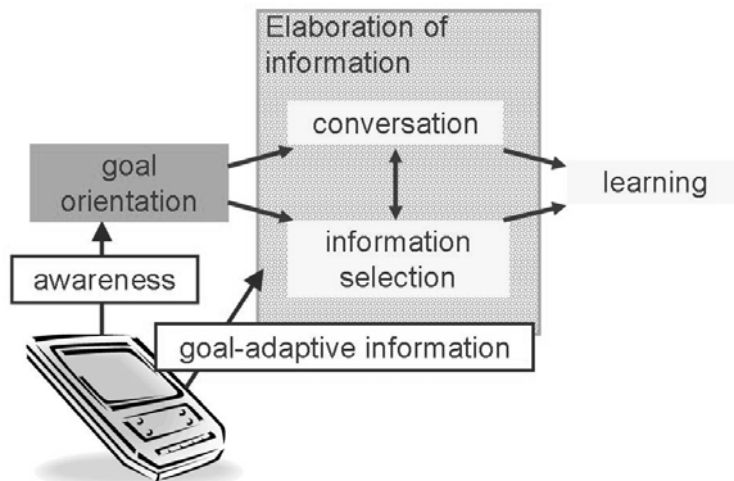
Often mobile media applications in the museum draw off attention from the exhibited objects and from communication in the group (Walter, 1996). Therefore attention should be paid to the design of media applications in a way that guides and promotes examination of and communication about the exhibit (cp. Suthers, 2001). In this dissertation users will be provided with one shared PDA and therefore are more likely to stay together and communicate. Also exploration in the dyad is fostered by selection of a shared goal.

Chin (2001) recommends evaluation of user-adapted systems. In this dissertation I want to go one step further: By designing technology based on results of psychological and museum research clear predictions can be made about the impact of technology on visitor behaviour and information processing. Systematic variations of technological aspects in experimental studies can give further insight in the cognitive processes initiated by different features of the technology.

## **2.5 Research Questions**

The main research question in this study is whether awareness of shared goals and goal-adaptive information presentation can enhance collaborative learning in an informal setting. This process is expected to be mediated by goal-orientation and elaboration of information (see figure 2). It is assumed that awareness of shared goals enhances goal orientation. Goal orientation in turn influences elaboration of information (information selection, conversation). By adapting information to a certain goal less mental effort is needed to connect information

with prior knowledge and the shared goal and more mental resources for deep elaboration are available. This should further enhance learning of goal-relevant knowledge.



**Figure 2.** Assumed impact of technology on collaborative information processing in museums

Another research question is on the availability of physical objects: Is information selection, conversation, and learning experience similar in real, authentic settings compared to digital objects in a virtual museum? As the importance of goal orientation was shown in hypertext as well as in museum learning similar results can be expected regarding the effect of goal-oriented learning with digital and authentic objects.

In addition to these questions a methodological goal of this dissertation – not further elaborated here – is to find out whether a laboratory setting provides an opportunity to do research on informal learning environments. Can results from the laboratory be transferred to real informal settings? It is assumed that most results can be transferred if a laboratory study is designed carefully. But there must also be expected some differences between these settings.

### 3 Experimental Research

Empirical research in the virtual museum context was done from January to March 2007; first results will be presented at the IMCL conference.

#### 3.1 Material

An exhibition about nanotechnology („Nanodialogue“ by the European Commission) serves as research setting in this project. The physical exhibition will be available in the lab for some month and afterwards in a real museum. A virtual museum – identical in content and complexity – was designed. For all exhibits, four parallel text sets were created providing differing information serving four different goals.

#### 3.2 Research Design

Participants of the two studies are randomized to four different experimental conditions (see table 2): Participants in condition 1 and 2 are made aware of their shared goals prior to their exploration of the exhibition. In condition 1 and 3 participants are given adaptive information according to their shared goal during exploration of the exhibition.

**Table 2.** Experimental design

		goal-adaptive information	
		yes	no
goal- awareness	yes	condition 1	condition 2
	no	condition 3	condition 4

To address the second research question, the study is conducted in two different contexts: In the virtual museum and in the lab museum. The exhibition content is always the same.

A smaller, third study will be conducted in a real museum under “natural conditions” to address the third research question.

### 3.3 Procedure

20 dyads of acquaintances per condition are recruited for a study on communication in museums (cover story to avoid formal learning orientation).

At the beginning of the study participants are familiarised with the technology (graphical hypertext or PDA). Participants in conditions 1 and 2 are then encouraged to choose from a list of goals which are met in the exhibition the most interesting one. In this way they are made aware of their shared goals. In condition 1 information will be adapted to these shared goals of participants. In condition 3 visitor behaviour will be monitored and will be the basis for implicit information adaptation. Participants visit the exhibition at their own pace without time constraints. In the laboratory museum they are provided with one PDA per dyad. In the virtual museum they explore the exhibition together in front of one screen.

After their visit participants are asked to fill out a questionnaire on their knowledge, satisfaction with the visit, prior knowledge, interest in the topic, mental effort needed, acceptance of the technology, and their subjective degree of goal orientation.

### 3.4 Analysis

Information selection during the visit will be traced by the PDA’s location system or hypermedia log files and will provide data on selection of exhibits, time spent at exhibits, and overall visiting time. Microphones will be used to record visitors’ dialogues which can be analysed with respect to shared goal and information selection, information evaluation, and conversational elaboration.

Comparison between the four experimental conditions will provide insight into the influence of goal-awareness and goal-adaptive information presentation on information selection, conversational elaboration, and knowledge acquisition in an informal learning setting. By comparing the laboratory and the virtual museum study, knowledge is gained about differences in goal-oriented learning in real-life and virtual informal settings. Also, both settings will be compared to the third study in a real museum to ensure external validity of findings gained from the two experimental laboratory settings.

## 4 Contribution to IMCL

Informal learning settings are important sites of life-long learning. In this study a specific informal learning setting, the museum, is addressed. Based on analysis of psychological, science education, and museum research, features of the setting are identified that could be obstructive to learning. These results can give helpful hints for design of educational technologies.

In this study an adaptive system – mobile and hypermedia – is suggested for informal learning settings. As intrinsic learning motivation exists less often in informal settings the diversity of

users' needs has a higher impact as in formal settings. As they can come up to these individual needs adaptive systems should be of special value in informal settings. One goal of this study is to give further insights into benefits of adaptive systems.

Psychological research methods, in this case experimental studies, allow conclusions about the learning potential of a technology's differential features by systematic variation of relevant aspects.

Reciprocally, I hope to benefit from presented technological solutions for adaptive systems. I also hope to get an insight into the current state of mobile and adaptive technologies and get some new ideas for psychological research.

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## Author:

Eva Mayr, Mag.  
 Virtual Ph.D. Program  
 University of Tuebingen, Applied Cognitive and Media Psychology  
 Konrad-Adenauer-Str. 40  
 72072 Tuebingen (Germany)  
 Mail: e.mayr@iwm-kmrc.de