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Design Guidelines for Context-Aware Creativity Support Systems

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Abstract

Ubiquitous computing and context-awareness have become a major factor and opportunity for various fields of computer science. Especially with the increasing usage of mobile devices and the spatial coalescence of work and personal life, ubiquitous computing has brought many opportunities for context-aware software. Creativity support has already found its way to computer science and various creativity support systems have been developed and used. While research about group creativity and individual creativity addresses problems of ineffective teamwork, less research has been done considering the creative environment. In our literature review we identified several environmental conditions, which influence creativity. Furthermore we disclosed recent sensory technology to capture context information. From these findings we propose design guidelines for context-aware creativity support systems

Keywords: creativity, context-awareness, ubiquitous, creativity support

Introduction

For a permanent success of an organization it is important to be innovative. Creativity as the source of innovation is therefore essential for the survival in a market. In such competitive markets, innovation is a continuous process, which requires employees to be creative over a long period of time (Porter & Linde, n.d.). Organizations aim to improve the working environment of their employees and try to enhance the creative working process (Amabile, 1996). Numerous methods to enhance creativity, such as Brainstorming, have already been conducted in organizations and are common practices in daily business (Fischer, Giaccardi, Eden, Sugimoto, & Ye, 2005; Osborn, 1953).

By now, creativity support has found its way into computer science, whereby different creativity support systems (CSS) were developed, evaluated and used in organizations (Fjermestad & Hiltz, 1998; Nunamaker, Applegate, & Konsynski, 1987; Shneiderman, 2007). These systems try to support individuals or groups based on different creativity support methods (Nunamaker, Briggs, Mittleman, Vogel, & Balthazard, 1996). CSS can help people to organize and evaluate ideas and even foster creativity in an idea generation stage with different creativity techniques (Bawden, 1986; Forster & Brocco, 2008; Shneiderman, 2007). Implementations of these systems are mainly stationary desktop-based

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creativity support systems and therefore creativity is often tied to a certain place (Nakakoji, 2005; Shneiderman, 2007). The increasing usage of mobile devices with its variety of built-in sensors turns ubiquitous and pervasive computing into a day-to-day custom (Abowd & Mynatt, 2000). The interaction with information systems is integrated into the daily life and is thus influenced by the environment and the context of the user (A. Schmidt, 2010). This context can, on the one hand, help software engineers to develop a better interaction with the user and, on the other hand, help to understand the influence of the context towards different behavioral and usage characteristics. Thereon context-aware computing offers organizations the ability to improve their productivity by better reacting to the users context (Chang, 2013).

As research on the influence of the working environment shows that the context of an individual or a group affects the creativity (Amabile, 1996; Csikszentmihalyi, 1997), creativity support systems should consider the users context. Because organizations try to foster the creativity of their employees, a creativity stimulating working environment is the major focus of companies (Amabile, 1996; Shalley & Gilson, 2004; Stokols, Clitheroe, & Zmuidzinas, 2002). However, creativity appears ubiquitous and especially outside of the working environment (Csikszentmihalyi, 1997). With the rise of modern technologies, electronic tools and mobile devices, work occurs away from the traditional office and the separation between personal life and work dwindles (Gant & Kiesler, 2002; Hill, Ferris, & Märtinson, 2003). This results in a different perception, where the context of the user has to be considered and analyzed for designing creativity support systems. Creativity support should therefore be ubiquitous and research should be done on how the context plays a role in creativity support.

Numerous researches were done on creativity support systems and different design principles, guidelines and frameworks have been developed, without considering any context information (Resnick et al., 2005; Voigt & Bergener, 2013). In their literature review Seidel et al. (2010) identify an underrepresentation of research of the creative environment. Only three studies address the creative environment, whereas most knowledge management issues are addressed. In addition to that, context-related frameworks and constructs play an even lesser role in research. Furthermore it is stated that creativity is neglected in IS research and especially "few studies explain how IT should be designed in order to support the creative process appropriately" (Seidel, Müller-Wienbergen, & Becker, 2010).

In our research we develop design guidelines for context-aware creativity support systems (CACSS). We focus on research from the fields of creativity support, the creative environment and on context-aware and ubiquitous computing and their underlying technology. Based on these findings we propose design guidelines for CACSS, which are capable to capture a user context and take context-dependent actions. These guidelines can be applied to any creativity support systems and help users or moderators of idea sessions to

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improve the environment they are working in. These finding can help developers and researchers to implement and evaluate methods that take notice of the context and take relevant action to better support creativity.

Background and Related Work. Creativity is a widespread field that intersects with the research of psychology, cognitive science, philosophy, economics and technology (Boden, 2004). The following chapter gives a relevant background about creativity, ubiquitous computing and context-awareness with special regards to the intersection of creativity and context-aware computing.

Creativity and the creative environment

Creativity is a widely used term, which is not clearly defined nor distinctly operationalized (Parkhurst, 1999; Runco, 2004). A well accepted definition by Amabile (1983) says that a creative outcome is novel and appropriate, useful, correct or valuable to a specific task. In addition, creativity is a task that is heuristic and therefore implies that some process is required (Amabile, 1983). This process has also been identified by Rhodes (1961) in his definition of the four P's of creativity. In his model, the author proposes to differ from a holistic point of view in favor of four central features determining creativity. These are, the acting person himself (person), the creative process (process) and a resulting product (product). Thereby the person is exposed to, and interacting with its environment, which Rhodes referred to as pressure (press). All four perspectives connect to each other and in addition influence each other (Rhodes, 1961). This creative environment has a special value for companies that try to create an optimal workplace for their employees. Beside of factors like leadership, groups, and incentives, the working environment is essential for the creative success of employees.

Numerous studies, such as by Stokols et al. (2002) and Shalley and Gilson (2004) show, that there is a relationship between the working environment and employees' creativity. The working environment is influenced not only by social aspects but also by the physical environment (Shalley & Gilson, 2004; Stokols et al., 2002). The design of workplaces has a significant impact on the behavior and creativity of employees (Dul, Ceylan, & Jaspers, 2011). In their literature review Ceylan et al. (2008) identified indoor plants, lights, windows, materials and arrangement of the workplace as influencing factors on employees' creativity. But beside of the workplace characteristics, other context-variables such as sound, color, time, light and brightness can influence the creative process (Ceylan, Dul, & Aytac, 2008). Therefore, we focus on context-variables that are measurable by modern mobile devices.

Groups can be stimulated not only by other group members but also by giving diverse stimuli from a support tool (Connolly, Routhieaux, & Schneider, 1993; Santanen, Briggs, & Vreede, 2004). To aid the development of a group creativity support system, different frameworks and design principles were already compiled. These frameworks provide components and functionalities that deal with creative characteristics in particular with group dynamics (Resnick

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et al., 2005; Voigt & Bergener, 2013). Although many creativity aspects have been addressed, context-awareness has been neglected.

Ubiquitous computing and context-awareness

Ubiquitous computing describes the possibility to compute everywhere, as almost all mobile computer-like devices today are connected to the Internet. In the course of the increasing popularity of mobile devices and the effective usage of these devices, the term ubiquitous computing was first described by Weiser in 1991 (Weiser, 1991). According to this, computation does not occur only in a specific location, but occurs everywhere. Therefore, it is not only the interaction with the user that is important, but also a multiple span of situations, interactions and variables (Schilit, Adams, & Want, 1994).

As the term context is widespread and used in different fields (Dey, 2001), in information systems the context can be described as followed: the context represents all environmental parameters of a human-computer occurrence (Albrecht Schmidt, Beigl, & Gellersen, 1999). A first definition by Schilit et al. (1994) names three main features of context: location, people and objects, and the resources of the environment (Schilit et al., 1994). Future definitions add physical parameters like the time, season, temperature, light and color to the definition of the context (Brown, Bovey, & Chen, 1997; Ryan, Pascoe, & Morse, 1998). Whereas other approaches additionally consider mental thoughts, personal situations, and social aspects as part of the context (Dey, Abowd, & Wood, 1998; Hull, Neaves, & Bedford-Roberts, 1997; Ryan et al., 1998). Abowd et al. (1999) generalize the definition of context in 1999 as every information that can be used to describe a situation and an object (Abowd et al., 1999). Context-aware computing is therefore defined as the ability to acquire the changing context. Applications are aware of their context and can then adapt and react according to the context (Chang, 2013; Schilit et al., 1994).

Research method

Systematic literature reviews as the proposed approach by Webster and Watson (2002) follow various steps to identify and analyze the correct literature (Webster & Watson, 2002). Especially the field of information system challenges researcher, as IS comprises a variety of interdisciplinary fields, which makes it difficult to identify all relevant literature (Levy & Ellis, 2006; Webster & Watson, 2002). The range of creativity literature is wide and intersects with different other research fields. In our concept-centric literature review we first identified relevant search terms, based on our research motivation and key variables, e.g. (1) the creative environment and creativity influencing factors, (2) context-awareness and ubiquitous computing. Our research was divided into two parts, where part one identified literature about creativity influencing the environmental conditions, and the second one identified literature about sensory technology that can capture the identified context.

Due to the interdisciplinary field of creativity, we used different databases for

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our research. The majority of publications were found in the ACM digital library, the JSTOR digital library, SpringerLink and the APA database. In addition, we used Google Scholar for our research. Publications about sensory technology were mainly found in IT-related databases. We limited our selection to full papers and journal articles with research results in order to develop our design guidelines. In addition to this, we concentrated on measureable context conditions that influence creativity. We also considered research results about social influence, such as leadership, incentives and motivation but omitted these factors in our guidelines, as they are not automatically measureable. We identified the following measureable context conditions: sound, noise, brightness, color and temperature. We then extended our search to these factors and additionally started a backward search. Overall we identified 40 articles from the field of creativity and the creative environment.

In regard to sensory technology and context-awareness, we concentrated on articles that present recent developments and sensors used in mobile devices. Overall we identified 20 articles disclosing sensory technology, which are already build in different devices and are able to capture the presented measureable creativity influencing factors. We then established a connection of creativity in context and context-aware computing by setting design guidelines for effective context-aware creativity support. Our design guidelines aim to aid developers to implement applications, by providing a variety of theories (Gregor, 2006; Malone & Crowston, 1990).

Sound and noise

The principle that anyone who wants to do mental work should do so in a possible quiet, undisturbed environment, remains unbroken (Evans & Johnson, 2000; Furnham & Strbac, 2002). Several studies have therefore concluded that background noise would cause stress and thus hinder creative work (Hillier, Alexander, & Beversdorf, 2006; Mehta, Zhu, & Cheema, 2012). The reason given is that parts of the brain are already occupied by the processing of the noise and less capacity would be available for other tasks (Söderlund, Sikström, Loftesnes, & Sonuga-Barke, 2010). In their study from 2012, Mehta et al. (2012) show that under some circumstances, a certain level of volume during creative work could actually be beneficial. Their experiments, in which the subjects were exposed to different types of background noise, show this (Mehta et al., 2012). In contrast to previous studies, participants were not exposed to artificially produced background noise, but familiar sounds like the soft sound of a television in the next room or the typical anonymous noise of a café. Mehta et al. (2012) conducted five experiments, in which the researchers presented the participants various tasks that required solving creative tasks and put them into a soundscape with different volume levels. All experiments showed that moderate noise levels (70dB) did not negatively affect neither the quantity, nor the quality of the solutions. In case of the quality even an improvement could be demonstrated under a moderate soundscape (Mehta et al., 2012; Söderlund et

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al., 2010). A high sound level (85dB) however impairs creativity. In 1994, Sundstrom et al. (1994) assessed the work performance in an office under noisy conditions. 54% of the 2391 participants of the field experiment were bothered by noise. Even so no negative work performance could be correlated with the noise, the field experiment showed that dissatisfaction could be linked with noise (Sundstrom, Town, Rice, Osborn, & Brill, 1994).

In summary: A noise level around and over 85dB impairs creativity, whereas a moderate noise level (up to 70dB) can positively affect creativity and the creative outcome.

Brightness and colors

An influence of brightness and light on the performance and cognitive tasks was found early on (Baron, Rea, & Daniels, 1992; Flynn, 1977). In favor of work environments, the main focus on the influence of light and colors was set on cognitive performance in order to help companies to create the most effective work environment. Baron et al. (1992) conducted three studies, which showed that the performance is influenced by the color and illuminance of light. Dim light (around 150lx) results in a higher performance and warm light motivates to resolve conflicts through collaboration (Baron et al., 1992). Knez (1995) evaluated the effects of indoor lightning via mood on cognitive performance. A relation between illuminance and the mood was identified, whereas it differed between the genders. Warm lights positively influenced the mood of female participants and cold lights influenced male participants. A relation between the mood and the cognitive performance was also identified (Knez, 1995). However in a later study, Knez and Enmarker (1998) found no effect of light towards the cognitive performance (Knez & Enmarker, 1998). Steidle and Werth (2013) conducted six experiments by especially evaluating the effect of light on creativity. The participants had to solve different tasks either in a creative or analytical way. Afterward, independent inspectors examined the outcome from various points, including the creativity of the solution. The findings led to the conclusion that a bright environment tends to encourage analytical processes, while a darkened environment seems to be conducive to creativity. The researchers conclude that dark environments rather invites for abstractive and exploratory thinking, since the person is more tolerant of inaccuracies in the information processing. This results in higher originality and creativity. Bright environments, however, favor rather analytical thinking by focusing on details (Steidle & Werth, 2013).

Colors have always been promised a special effect on people. McCoy and Evans (2002) evaluated colors only on their perceived temperature, e.g. warm and cold. The results show that cool colors have a negative effect on the creativity potential (McCoy & Evans, 2002). Colors can be particularly assigned to emotions, in which case cultural differences play an important role. It remains unclear, however, this relationship is generated by the color itself or

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subconsciously on experiences related to the colors (D'Andrade & Egan, 1974). Particular importance has the color red, which often comes as a situational signal color and a signal for danger or alert. Findings show that red can also impair performance (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). Especially when tasks require exactness, red and to a lesser degree also yellow can positively affect performance (Goldstein, 1942). Whereas colors like green and blue impair focusing on a task. Recent research adapts these findings and refers to the wavelength of colors. Longer wavelength colors (warm colors) are seen as provoking, whereas short wavelength colors (cold colors) calm down (Kwallek, Woodson, Lewis, & Sales, 1997; Stone & English, 1998).

In a study from 2011 by Lichtenfeld et al., the special significance of the color green has been demonstrated in several experiments. In one of the experiments, participants were given the task to list all uses of a simple tin can. The ideas should be unusual, but possible. The editing was done on the computer. At the beginning of the experiment, a splash screen was displayed, which was based either randomly colored green or held in a neutral white. Participants who previously faced the green welcome screen came up with ideas that had a better average rating. In three other experiments, this result could be confirmed (Lichtenfeld, Elliot, Maier, & Pekrun, 2012). The explanation for that is that humans associate nature and the growth and development of plants with the color green (Lichtenfeld et al., 2012). Thus especially natural environments, e.g. natural colors and natural light can impair performance and creativity. That's why the importance of windows in offices and working environments play an important role, as they provide natural light (Boyce & Cuttle, 1990; Heerwagen & Orians, 1986).

In summary: Illuminance is a key for creativity. Darkness or dim light (150lx) can impair creativity, especially in addition with warm light. Warm light can also motivate in solving tasks. Bright light might impede divergent thinking but can foster analytic thinking. In addition warm colors, especially red, impairs performance and green and blue can enhance focusing on a task up to improving creativity.

Temperature

Especially high and low temperatures have been evaluated as a main influence on work performance and cognitive tasks (Pilcher, Nadler, & Busch, 2002). However an effective temperature is difficult to determine as it highly depends on the task type, its complexity, the exposure duration and the skill level (Hancock & Vasmatzidis, 2003). Dull and simple tasks are only little influenced by heat and cold (Hancock & Vasmatzidis, 2003; Pilcher et al., 2002). Whereas heat and cold can impair high-complexity tasks, such as text processing and mathematical calculations. As creativity requires convergent and divergent thinking as well as analytic thinking, it can be seen as a complex task (Mumford, Medeiros, & Partlow, 2012) and is therefore influenced by temperature.

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Due to acclimation, short exposure of heat and cold is considered to have little or no effect on performance (Hancock & Vasmatzidis, 2003). However other studies see short exposure as even worse, due to acclimation (Enander, 1989; Pilcher et al., 2002). Even an improvement on simple tasks under short exposure of heat could be identified (Nunneley, Dowd, Myhre, Stribley, & McNee, 1979). In their comprehensive literature review, Pilcher et al. (2002) examined 226 studies about the influence of temperature on performance. They identified, that the worst influence has cold lower than 50°F (10°C) and heat higher than 90°F (32,22°C). A temperature between 70°F (21,11°C) and 79.9°F (26,61°C) has only little effect, e.g. the best evaluated effect, on performance. Whereas a temperature under 50°F (18,28°C) has especially negative influence on reasoning, learning and memory tasks. Temperatures over 80°F (26,67°C) are having most negative effect on calculations and attention tasks (Pilcher et al., 2002). Sappänen et al. (2006) identified a temperature around 71.6°F (22°C) as the temperature with the highest productivity (Seppanen, Fisk, & Lei, 2006).

A study from Hygge and Knez (2001) evaluated the interaction between noise, heat and lightning on cognitive performance. Little influence between all factors was found, which is why the possibility that indoor noise, heat and lightning act directly on cognitive performance seems likely (Hygge & Knez, 2001).

In summary: High complexity tasks like creative tasks are best at a temperature level between 70°F (21,11°C) and 79.9°F (26,61°C), whereas a temperature of 71.6°F (22°C) should be aimed for. Short extreme heat or cold exposure should be avoided as only no or negative effect on creativity was found.

Design guidelines

Our design guidelines aim for an effective use of context information to support creativity of individuals or groups. We identified various functionalities of different devices including laptops, tablets and smartphones that possess sensors for automatically measuring colors, light, noise and temperature. The design guidelines can be applied to any creativity support system, regardless if used online, offline, asynchronous, synchronous, by a single person or within a moderated group idea session. The goal of our guidelines is to reach for optimal context conditions by adjustments to hostile conditions.

One main sensor of mobile devices is GPS, with which the primary context variable, the location of the user, can be determined (Brown et al., 1997; Gellersen, Schmidt, & Beigl, 2002). With the GPS data, other services can then determine secondary context variables such as weather, temperature, place (city and environment classification) and more. The temperature can also be determined by a thermometer, which is built in many mobile devices. A primary temperature sensor like a thermometer is therefore superior, as it can measure more precise and especially measure inside buildings (Keränen et al., 2010; Korpipää, Mäntyjärvi, Kela, Keränen, & Malm, 2003; Nield, 2014). Hence the first

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design guideline is:

DG1: *A built-in thermometer should be used to constantly measure the temperature. If the temperature is out of the optimal range [70°F (21,11°C) - 79.9°F (26,61°C)] the temperature has to be adjusted up to the optimal temperature of 71.6°F (22°C).*

Many mobile devices possess ambient light sensors (ALS) to adjust the brightness of the display according to the ambient illuminance (Korpipää et al., 2003; Lane et al., 2010). Recent mobile devices are moreover equipped with RGB sensors, which are able to measure the color temperature in order to drive intelligent display adaption (Lane et al., 2010; Nield, 2014). As it is possible to measure illuminance and color, our second and third design guidelines are:

DG2: *ALS sensors should be used constantly to measure illuminance. If the illuminance in the idea generation stage is higher than 150lx, the light has to be adjusted. In the idea improvement or idea evaluation stage, the illuminance can be higher.*

DG3: *RGB sensors should constantly measure the color temperature. The interface colors should be appropriate to the idea stage. During the idea generation, warm colors should be used in the interface design and the user should be prompted to adjust (might result in changing the location) if the light color is cold (green, blue etc.). During idea improvement and idea evaluation cold interface colors can be used and warm light colors should be altered.*

For sound recording, video conferencing and phoning, devices have one or even more microphones. These microphones can be used to measure any sound and noise in the environment (Clarkson, Sawhney, & Pentland, 1998; Lane et al., 2010; Nield, 2014). Especially the sound volume is important for our fourth design guideline:

DG4: *Microphones should constantly measure the volume level. If the sound volume is close to or higher than 85dB, the sound and noise level should be adjusted.*

The stated design guidelines propose basic guidelines to adjust different context conditions. Application designers should define exact prompts and methods according to the type of the creativity support system. Primarily our guidelines aim to make use the sensors, which can detect creativity impairing conditions. An important aspect of our guidelines is therefore not how to react in particular, but at least to react to an ineffective condition. In addition, designers should collect data over the time of usage to optimize the CACSS. Even though all stated context conditions could influence cognitive performance and

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creativity, not all guidelines have to be considered and implemented, because a single condition can already impair or foster creativity. The following figure presents all four design guidelines and the equivalent context condition.

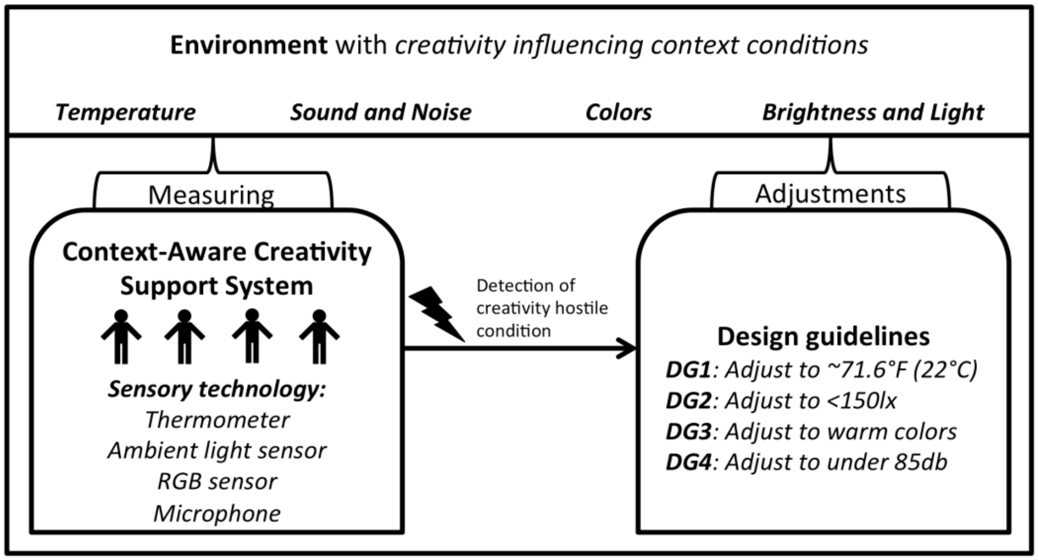

Figure 1. Design guidelines for CACSS

Use case of the design guidelines

We developed these guidelines in the course of an ongoing project that deals with the digitalization of ideation techniques for innovation workshops. In search for new methods for small and medium-sized companies, which struggle to innovate novel industrial services, our methods aim for a more effective innovation process. These methods are implemented and evaluated in workshops with industrial service companies. By the growing number of cross-divisional expertise, for resolving particular problems, these workshops include, not only employees of the company, but also customers and other external stakeholders (Lipnack & Stamps, 1997; Townsend, DeMarie, & Hendrickson, 1998). Thus, a permanent and specific location for the workshops is not possible and therefore has to be flexible.

As rooms, that are especially designed and equipped for creative workshops are not always available, we implemented specific creativity supporting techniques into a creativity support system that runs on mobile devices. This system plays an important role during the workshop and the creative process, as every workshop participant uses the system on a tablet computer. In order to establish the most effective creativity conditions, we now will make use of the sensory technology of the mobile devices and will measure the stated context conditions during the workshops according to our design guidelines. The workshop moderator will then be able to maintain and adjust possible hostile creativity conditions at each different workshop location.

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Conclusion and outlook

With our comprehensive literature review we contributed valuable theories about creativity support and the creative environment. We identified various studies about work performance and office related work environments, whereas studies about context-awareness in creative processes and IT related studies about creativity in context are rare. With the development of new sensors and the integration into various devices, it is possible to use these sensors to support creativity. We disclosed these possibilities in order to avoid creativity hostile environments and benefit from adjustments. In favor of design science research in IT, we developed design guidelines that can help developers to better implement context-aware functionalities for creativity support systems. Our design guidelines provide basic information about how a creativity support system can make use of build in sensors that can measure temperature, brightness, color and sound. These design guidelines require individual implementation as creativity support systems operate in different ways and with a different number of involved people. With our specific use case, we provide a practical example for an implementation of the guidelines. In addition, not every device can measure every single context condition, which is why some conditions cannot be captured automatically or adjusted. Moreover other context conditions such as time, weather and possible creativity stimulating objects (Csikszentmihalyi, 1997) were neglected in our study. Time and weather cannot be adjusted. Objects in the environment are difficult to automatically capture and have to be individually analyzed by their stimulating quality. The majority of our analyzed studies, deal with the influence on performance, not especially on creativity. Even so, cognitive performance is a major factor of creativity. The actual influence on creativity and the creative outcome was only addressed by a few studies.

Moreover, a literature review has always limitations. We are aware of the fact that there is a possibility of missed studies, which could provide additional information for our design guidelines. But especially the fact that there is no research about context-awareness in creativity support systems makes it important to do further research about how CSS can improve creativity by interacting with the context. Therefore, evaluations of the benefits of our design guidelines should be done. This includes research on how a certain reaction to an ineffective context conditions can improve the creative process or even the creative outcome. In summary, we can say that designers should use sensors to measure creativity influencing context conditions and design methods on how to adjust impairing conditions if needed. With our intersecting research, we reduced the gap between context-awareness and creativity support, however still further research is needed on how the environment can influence creativity and how modern technologies can benefit from the interaction with the environment.

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