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RESEARCH PERSPECTIVES ON CREATIVE INTERSECTIONS

Inspiration Space: Towards a theory of creativity-supporting learning environments

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Building on the assumption that the physical environment can have an influence on the creativity of designers and design students in particular, the aim of this paper is to provide theoretical propositions and evidences for this relationship. We develop various propositions about the influence of physical environments on creativity, based on eight expert interviews and supported by literature. A particular focus was given to the environments of design educational institutions. We present a summary of the main insights and visualize the developed propositions as a causal graph addressing how space influences creativity. These propositions can be regarded as a first step towards a theory of creativity-supporting learning environments and they can serve as a reference when designing or adjusting creative learning spaces.

keywords: workspaces for design, creativity, design education, creative learning space

Introduction

Background

Educating future designers is more than just designing curricula, lecturing students, and assigning project work: one of the probably least considered aspects in design education is the physical environment, although it can be argued that it potentially has an impact on students' creativity, wellbeing, and learning performance. The questions whether a space

can facilitate the learning process, enhance the wellbeing of students and teachers, and most notably foster creativity and innovation have remained under-researched. Simultaneously, an increased interest in creative learning environments is emerging in the area of elementary schools and kindergartens (e.g. Boys, 2010; Dudek, 2000; Ehmann, Borges, & Klanten, 2012; Kaup, Kim, & Dudek, 2013). However, not many studies have been conducted on the realm of adult design educational environments (design schools and universities). Therefore, this paper aims to derive a theoretical foundation on 'creative learning spaces', based on a systematic empirical and theoretical investigation of the topic.

Related Literature

There is a long history of research that investigates the effects of space on work productivity (e.g. Oseland, 1999). In the last decades, creativity and innovation became a bigger part of work, and therefore the interest in the connection between space and creativity grew (Dul & Ceylan, 2014; Dul, Ceylan, & Jaspers, 2011; Kristensen, 2004; Lloyd, 2001; Moultrie et al., 2007). There are only few papers that looked at creative learning spaces in design educational contexts (e.g. Cannon & Utriainen, 2013; Jankowska & Atlay, 2008; Jones & Lloyd, 2013; Leurs, Schelling, & Mulder, 2013; Setola & Leurs, 2014; Weinberg, Nicolai, Hüsam, Panayotova, & Klooker, 2014). However, to the best of our knowledge, there is no paper that tried to create a systematic and evidence-based theory for creative learning spaces, which is the objective of this paper.

Creativity

There exist numerous definitions of creativity. Most authors distinguish between creativity as an outcome (a creative solution) and creativity as a process. Creativity as an outcome should be novel (in terms of being original, unique, and surprising), meaningful, and useful at the same time (e.g. T.M. Amabile, 1996, 1996; Boden, 1996; Sarkar & Chakrabarti, 2007; Sawyer, 2006; Stein, 1953; Sternberg, 1988; Weisberg, 2006). Gero (1996) added 'unexpectedness' to this definition, and Simonton (2012) added 'surprise'. Creativity as a process, on the other hand, was first described by Wallas (1926), as a four-step creative problem solving process consisting of:

- Preparation (investigation of the problem in all directions)
- Incubation (unconscious processing)
- Insight / Illumination (sudden creation of a solution)
- Verification (critical elaboration and validation of the idea)

Building on this, Guilford (1950) introduced the concept of divergent and convergent thinking, as a mode of thinking to explain creativity. Diverging means producing a large quantity and variety of ideas, whereas convergent thinking describes the process of narrowing down to one solution—a concept that nowadays is also very popular in design thinking (Brown, 2009). Later, Guilford differentiated between *flexibility* (the variety of ideas; diverging into different directions) and *fluency* (the quantity of ideas produced) as important elements of a creative process (Joy Paul Guilford, 1967).

Since our interest focuses on the ability of the built environment to facilitate a creative working and learning *process*, the definitions of *creativity as a process* are more relevant for our study. Hence, our research question is centred around the questions if, and if yes how, the learning environment of a design school can facilitate (a) *flexibility* of ideation

and (b) *fluency* of ideation, as well as (c) how it can provide appropriate spaces for *preparation*, *incubation*, *illumination*, and *verification*. Additionally, other creativity concepts, such as *fixation* (the inappropriate repetition of existing solutions, (e.g. Cardoso & Badke-Schaub, 2011; Jansson & Smith, 1991; Purcell & Gero, 1996)), *priming* (the activation of a specific—for example creative—mindset (e.g. Sassenberg, Moskowitz, Fetterman, & Kessler, 2017)), and *serendipity* (the unexpected finding of valuable ideas, persons, and things, (e.g. Goldschmidt, 2015; Meusburger, Funke, & Wunder, 2009)) will guide our analysis process.

Previous work

To structure our study, we refer to a 'Typology of Creative Learning Space' (adapted from Thoring, Luippold, & Mueller, 2012a) that outlines five different types of creative learning spaces, as well as five different qualities, which can be a characteristic of such a creative learning space. The space types are: personal space, collaboration space, presentation space, making space, and transition space. The qualities are: space as a knowledge processor, space as an indicator of (organizational) culture, space as a social dimension, space as stimulation, and space as infrastructure. Figure 1 illustrates the different types and qualities of creative learning spaces.

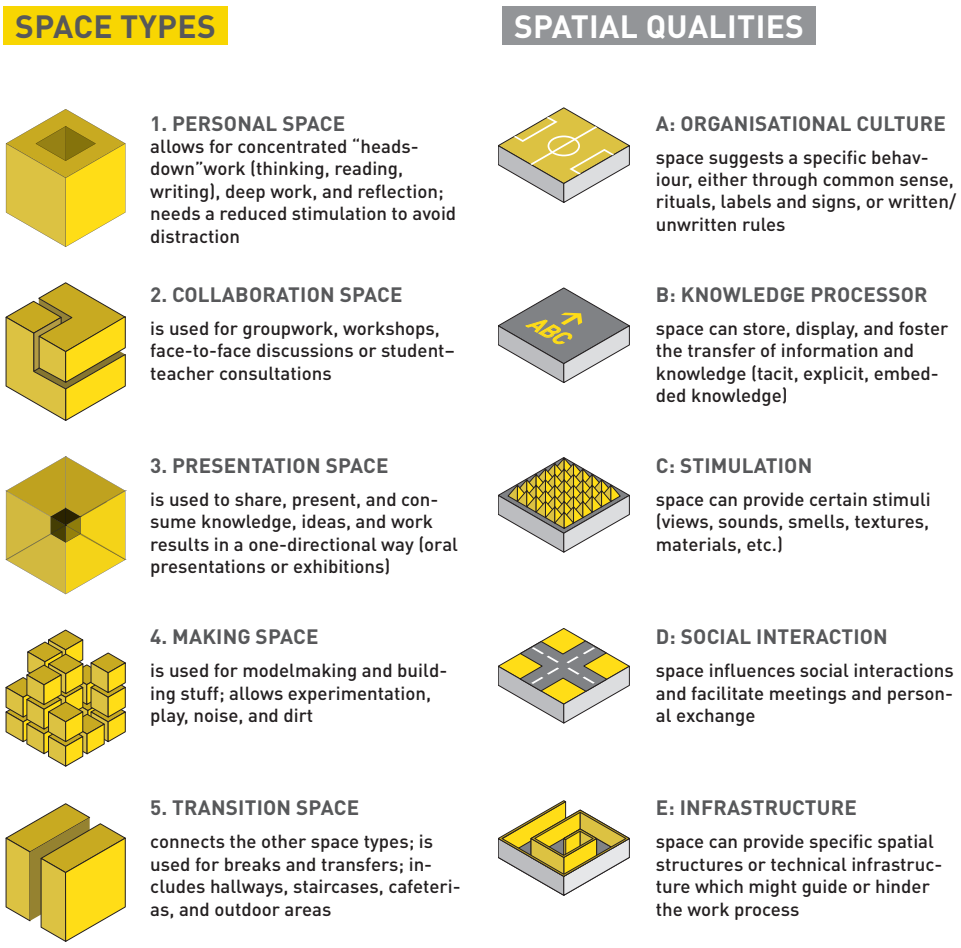

Figure 1 Typology of Creative Learning Spaces (adapted from Thoring et al., 2012a)

Methodology

Theory Development

The objective of this paper is to present the groundwork of a novel theory about the influence of the built environment on creativity. According to Popper (1934) a theory is an abstracted model of the reality. Building on that, Gregor (2006) differentiates between five types of theories: Type 1 Theories for Analyzing that only describe and analyze the reality, for example as a typology (*what is?*). Type 2 Theories for Explanation that attempt to provide explanations for specific incidents (*what is, how, why, when, and where?*). Type 3 Theories for Prediction that provide predictions but without causal explanations (*what is and what will be?*). Type 4 Theories for Explanation and Prediction that provide predictions and also testable propositions and causal explanations (*what is, how, why, when, where, and what will be?*). And Type 5 Theories for Design and Action that suggest explicit prescriptions for constructing an artifact (*how to do something?*). The presented paper constitutes a Type 4 Theory as it aims to provide explanations for and predictions of the possible impact of spatial specifications on creative performance. The presented hypotheses are testable, however, an actual test is not part of this paper. We provide evidences for each presented hypothesis that are based on expert interviews and supported by related literature. Similar to evidence-based management (Pfeffer & Sutton, 2006), we aim for evidence-based creative spaces, beyond hype and fashion. Our presented hypotheses are probabilistic, not deterministic, which means we search for factors that make the outcome in general more likely (Jaccard & Jacoby, 2009). We do not claim that these hypotheses are valid for everybody in all circumstances. Instead, we are interested in the rich insights of possible contingencies. Therefore our main sources for the hypotheses are—next to the literature—qualitative interviews and cases. We propose a qualitative probabilistic causal theory (Pearl, 2000) of creative space. In the future we want to build upon this and develop the theory further into a Type 5 Design Theory (Shirley Gregor & Jones, 2007) with design principles (how to design creativity-supporting environments).

Expert Interviews

We conducted 8 semi-structured interviews with experts from the fields of Design Education, Innovation, Product Design, Workplace Furniture, Architecture, and Interior Design. Those experts were chosen to cover a wide variety of different perspectives on the topic of creative learning environments within the three clusters of interest: Design, Education, and Space.

For the design group (DES) we included interviews of two design practitioners (one working in a leading position at the major design agency IDEO, the other one running her own studio). For the group of educators (EDU), we included three experts from various design disciplines and different design universities (a professor for urban design, a professor for strategic design, and a professor for design thinking and innovation). And finally, for the group of architecture, interior architecture, and furniture (ARCH) we included three interviews: one architect, specialized in design educational buildings, one interior architect, specialized in innovation spaces, and one furniture manufacturer, specialized in educational furniture. The chosen experts also represent a cultural diversity in terms of their country of origin and their place of work, in order not to limit the insights

to one particular national culture. The covered nationalities include German, US-American, Venezuelan, and Swedish, while their places of work include also Denmark, Switzerland, and Austria. Table 1 shows an overview of the included interviews.

Table 1 *Overview of Expert Interviews*

No.#	ID	Years of Experience	Main Expertise
1	DES-1	15+	Design Manager at IDEO in US and Germany
2	DES-2	10+	Spatial designer and artist
3	EDU-1	20+	Professor for Urban and Social Design
4	EDU-2	30+	Writer and Professor for Innovation
5	EDU-3	20+	Professor for Strategic Design
6	ARCH-1	5+	Lead of interior design of D-School
7	ARCH-2	10+	Lead of architectural Design Umeå Design School
8	ARCH-3	15+	European Manager at Steelcase for Educational Furniture

The semi-structured interviews were guided by a set of open questions (the full interview guideline is available upon request). The interviews were structured into two main parts: First we asked about experiences or thoughts related to the five space types and five spatial functions (as outlined in Figure 1—the typology of creative learning spaces). The second set of questions related to general characteristics of a space (materials, colours, furniture, etc.) and what impact these might have on creativity, wellbeing, and learning. The interviewees also ranked these characteristics to indicate their priorities. Finally, the interviewees were asked about their personal experiences and preferences within their own working environment. All questions were open and allowed for the sharing of personal insights and stories, also beyond the prepared questions. The interviews were audio-recorded and later transcribed (non-verbatim). The final eight interviews had a total of 9.7 hours of audio data—an average of 72 minutes per interview. The interviews were transcribed and imported into Atlas.ti for further analysis.

- The following code structure was developed in order to analyse the data. The code structure consists of 5 groups with 178 codes in total:
- group 1 = Impact
  contains 3 codes (Creativity, Learning, Wellbeing). For this paper only "creativity" is analysed.
- group 2 = Evaluation
  contains 4 codes (positive evaluation, negative evaluation, high priority, low priority)
- group 3 = Space Types (according to the Typology outlined in Figure 1)
  contains 33 codes; 5 codes for the space types (individual work space, collaboration space, making space, presentation space, and transition space),

and 28 subcodes with exemplary spaces for each space type, according to the typology presented in the introduction (e.g. CollaborationSpace>Classroom, CollaborationSpace>Studio, etc.)

- group 4 = Space Qualities (according to the Typology outlined in Figure 1) contains 26 codes; 5 codes for the spatial qualities, according to the typology presented in the introduction (Culture, Infrastructure, Knowledge Processor, Social Dimension, Stimulation), and 21 subcodes with exemplary qualities for each category (e.g. Stimulation>Inspiration, Stimulation>Distraction, etc.)
- group 5 = Space Characteristics
  contains 111 codes; 16 codes for the spatial characteristics (Atmosphere, Climate, Colours, Flexibility, Furniture, Health Issues, Light, Location, Materials, Objects, Plants and Flowers, Room Layout, Smells, Sound, Style, Technology, View), and 95 subcodes with exemplary characteristics for each category (e.g. Atmosphere>Playful, Atmosphere>Homely, etc.)

The interview data was coded by two researchers. Any arising question during the coding process was discussed immediately until an agreement was found. The first step of the analysis process was to filter all data against the code 'creativity', because the main objective of this study is to investigate the possible impact of the space on creativity. The data was coded with this term in cases where the experts mentioned the term 'creativity' either autonomously, or after prompts from the interviewer, and where quotes appeared that were talking about closely associated aspects such as 'innovation' or 'idea generation'. Thus 86 text segments were coded with 'creativity' and served as the basis for the development of the propositions. Further analysis and interpretation led to propositions about the possible impact of space on creativity. In a second step, these identified segments were checked against other codes that appeared in close proximity, as these aspects might also have an influence on creativity as well. The resulting 161 adjacent codes were ranked according to the frequency of their appearance in the interview texts. The most frequent occurrences were the subcodes 'Stimulation-Inspiration' (10), ‚Atmosphere-Welcoming' (9), and ‚Atmosphere-Homely' (6). As these aspects might also have an impact on creativity, the entire data was cross-checked for these codes for new insights. Through this procedure, additional quotes were identified that appeared to be of high relevance for the spatial impact on creativity and were included in the analysis and the final development of 12 propositions. In the following section the developed propositions are described in more detail.

Propositions about the Impact of Space on Creativity

We present a set of 12 propositions that suggest an influence of spatial characteristics on creativity. Each proposition is based on quotes from the interviews. Supporting or contradicting literature is presented for each proposition, where applicable. Table 2 presents an overview of the identified propositions along with a link to related creativity definitions as described in the introduction of this paper, while Table 3 summarizes the related evidences (supporting or contradicting quotes from the interviewees as well as from the literature). Figure 2 illustrates the propositions (possible cause-and-effect relationships of spatial elements towards creativity) as a graph.

Table 2 Twelve Propositions

P#	Proposition	Explanation	Creativity Theory
P1	*Surprising Space*	strange, unexpected, imperfect space triggers curiosity and hence creativity, forces people to interpret and generate their own ideas	Illumination Flexibility Serendipity
P2	*Space as a Platform for Ideas*	space to manifest ideas; large space lets the mind expand and allows building and testing more and larger sized models	Fluency Verification
P3	*Creative Chaos*	triggers creativity as it prompts associations; if space is filled with old projects might lead to fixation	Flexibility Serendipity Fixation
P4	*Visual Stimuli*	visible materials, books, and other information can inspire new ideas and increase creativity	Preparation Flexibility Fluidity Fixation
P5	*Reduced Stimulation*	white space, empty space fosters creativity, invites people to project their own ideas into it	Incubation Illumination Avoid fixation
P6	*Tactile, Olfactory, and Acoustic Stimuli*	materials, smells, cooking, and sound inspire creativity	Incubation
P7	*Making Spaces*	Space that allows to make things manually fosters creativity	Verification
P8	*Open View*	Window view, inspires creativity, lets the mind expand	Incubation
P9	*Bodily Activity Movement*	visible movement or own movement (e.g. walking, sports) facilitates creativity	Incubation
P10	*Playful Experimental Atmosphere*	Games, toys invite to experiment, risk-taking, and allow failure; Ownership of space	Incubation Flexibility Verification
P11	*Creative Labelling*	designating a space for creative work, or historic creative surroundings can set a mood or mindset receptive for creativity	Preparation Priming
P12	*Social Interaction*	creative people are more important than space, so space should facilitate meeting and exchange	Flexibility Incubation Serendipity

In the following, each proposition is described in more detail and linked to related literature, where applicable. Furthermore, selected interview quotes are presented that support the respective proposition.

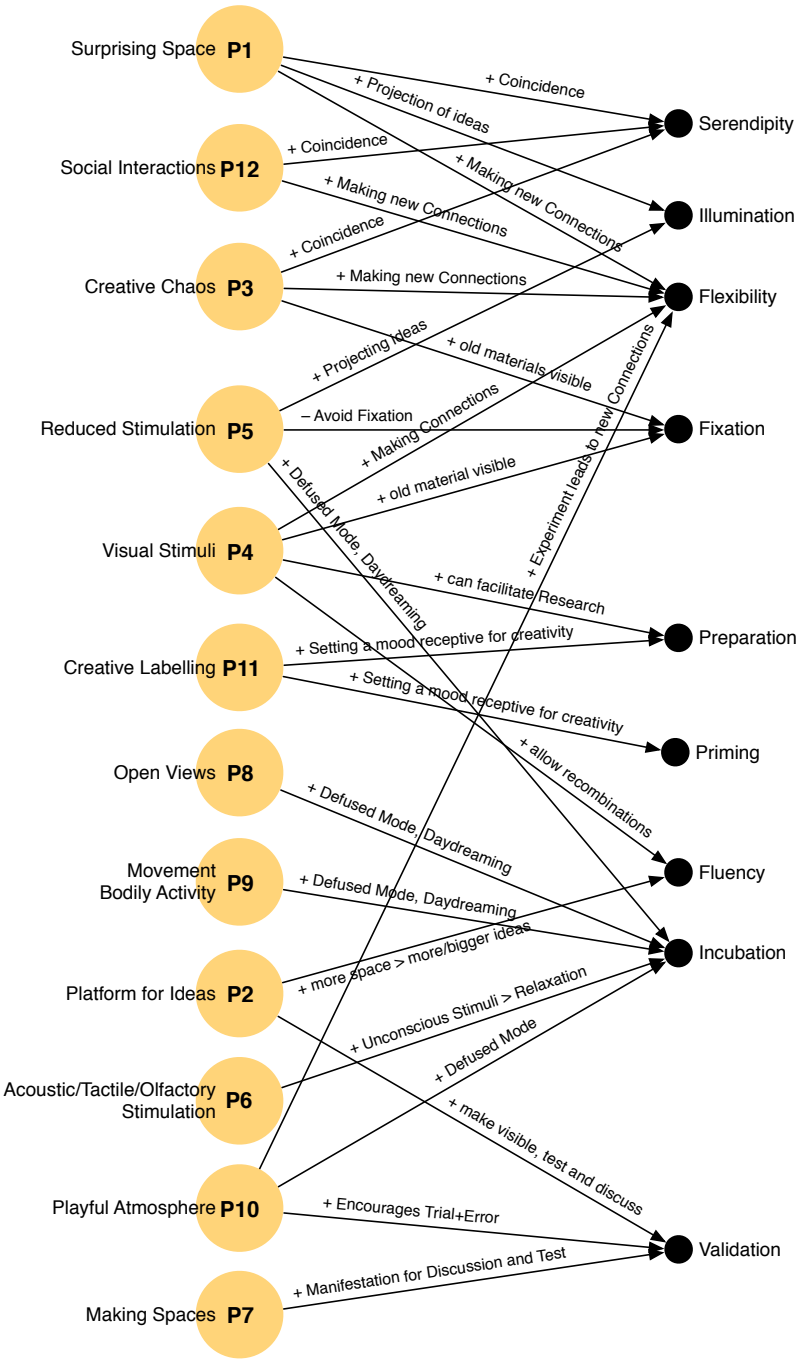

Figure 2 *Causal Graph illustrating the relationships and influences according to the propositions towards creativity (+ indicates increasing effect, – indicates decreasing effect).*

Proposition 1 (P1): Surprising Space

Strange, unexpected, or imperfect spaces, which have unusual shapes that result in 'dead' or unused corners, or reveal surprising interiors can have a positive impact on creativity. Students could use these spaces to implement their own designs or install small exhibitions. Such surprising, unexpected, or even defective spaces trigger curiosity, provide surprising stimuli and hence force people to interpret and generate their own ideas. This can result in an increased variety of ideas by establishing connections between disparate concepts (flexibility), or it can provide coincidences (serendipity), or result in a sudden idea (illumination).

> *Within this School of Architecture there were some spaces that are very tall, they're over 10 meters and only maybe one meter in wideness and they're not accessible of course. These started to be used by the students; they hang things there and for example they study how sound is being transported within such a room and they try to visualize that with the installations. Very inspiring how they attack the space. (ARCH-2)*

> *When I was working in this Frank Gehry Building you would think round fosters creativity and so on, but it was quite the opposite. There was no way of placing the tables inside that room. And when your space is constantly invaded because it's round and you have people walking behind you and so on. It just doesn't help you connect with the space. (EDU-3)*

According to Flipowicz (2006) surprise can cause a cognitive shift, which fosters creativity. Also, Grace and Maher (2015) suggest that surprising stimuli could enhance creativity. On the other hand, spaces that are too impractical, might result in quite the opposite. A good balance of surprising and functional spaces seems to be the sweet spot.

Proposition 2 (P2): Platform for Ideas

When working creatively you need some space to manifest your ideas. This can range from a post-it note, to a whiteboard, a writeable wall, or a huge studio to build things. The larger this platform, the more possibilities one has to manifest ideas, which can result in the generation of many solutions (fluency). The manifestations also allow to visualize, discuss, and validate ideas, together with others or as a testable prototype (validation). Also, a large space lets the mind expand and allows creating more or literally larger ideas (e.g. build larger sized models).

> *The size of the space is extremely important. I had a smaller Studio before and all my designs were smaller as well. A large space allows you to think bigger, create bigger ideas, and build bigger models [translated by author]. (DES-2)*

> *Ideas manifest creativity and that manifestation must be part of the process and you manifest in different ways: shop, studio, even if you are acting things out, you need a sort of stage. (EDU-2)*

Boundary objects (Star & Griesemer, 1989), such as sketches, canvases, or prototypes, are plastic enough for information to be adapted and interpreted differently by different communities, but robust enough to maintain informational integrity. They support distributed cognition by eliciting and capturing tacit knowledge through interactions with the boundary objects (Henderson, 1991). Boundary objects support social and individual

creativity in several ways: by moving from vague ideas to more concrete representations; by producing records of mental thought outside of the individual memory; by providing means for others to interact, critic, and build upon the ideas; and by establishing a common language of understanding (Fischer, Giaccardi, Eden, Sugimoto, & Ye, 2005). Space can establish a platform for these boundary objects and act as a boundary object itself—a sort of boundary space.

Proposition 3 (P3): Creative Chaos

Although the question whether creativity is fostered by a work space that is clean or messy largely depends on personal taste or culture, there are some interesting principles that can be derived about the concept of creative chaos.

> *I could not start a new project when the material from the previous one is still on my desk. Similarly, no one would stick the new post-it note on top of the old one. If you want to create something new you need to start fresh, to create new associations. Otherwise there's the risk to reproduce the same stuff again and again. During the project, however, it may be chaotic and messy. [translated by author] (ARCH-1)*

> *For me, messy is really inspiring. Yeah. I make connections when things are really messy. (EDU-3)*

Some of the interviewees were indifferent about creative chaos or mentioned positive as well as negative aspects of chaotic environments at the same time. A little bit of chaos is inspiring, but too much hinders the creative workflow. Moreover, the degree of acceptable chaos also depends on the project status. While chaos would be considered tolerable during a project (caused by the project's own materials), chaos produced by old materials from previous projects would be hindering at the beginning of a new project. This could be related to the concept of fixation, which suggests that visible material from earlier projects bears the risk of hindering one's creativity, by becoming stuck to those old ideas. On the other hand, in a chaotic environment new connections can be made based on coincidental material combinations or mistakes (serendipity), which can result in more variety of ideas (flexibility). Also, Clark (2007) describes chaos and order as two interconnected elements of the creative process that need to be in balance. Depending on the state of the project either one has advantages and disadvantages. Zausner (1996) suggests that a creative process shows non-linear dynamics and is hence always somewhat chaotic. Chaotic processes have both randomness and unpredictability, which can be explained by the creativity concepts of flexibility and serendipity.

As a conclusion, space should facilitate a good balance of chaos and order, for example by providing appropriate storage facilities.

Proposition 4 (P4): Visual Stimuli

Designers and design students often refer to visual stimulation for inspiration, which became also evident in most of the interviews.

> *And if I start putting things or paintings in the walls and stuff then I get a little bit distracted. […]. There are moments when distraction really pays off and I think visual distraction creates ideas. (EDU-3)*

…whereas inspiration comes from books and magazines [...] [translated by author] (EDU-1)

Gonçalves et al. (2014) investigated the inspirational approaches of designers and identified that there is a high preference for visual material, mainly from the Internet, but also from magazines and books. Goldschmidt and Smolkov (2006) present findings that the presence of visual stimuli is positively correlated with the emergence of creativity. Goldschmidt (2003) suggests that the exhibition of sketches, either self-generated or created by colleagues, elicits "backtalk" (i.e., reinterpretation and reflection of visual material created). Backtalk of sketches can then elicit multiple reinterpretations and potentially lead to creativity. Goldschmidt (2007) investigates team-shared mental models that are supported by sketches. Visual representations of work produced (sketches included but also posters and other visual outcomes of design projects) enable communication of ideas and convergence of mental models within team members. In the same way, visual stimuli in the form of past projects produced by students can establish connections across other students. Following this concept, visual stimuli can increase flexibility and validation. Van der Lugt (2005) claims that sketching can be used as a design team's 'external memory': Generated visual representations, such as sketches, can support reinterpretation of ideas, either individually and in group, and helps keeping track of the solution space already explored. However, visual stimuli might also trigger fixation effects as students can become too attached to visible material instead of developing their own designs (Cardoso & Badke-Schaub, 2011).

Proposition 5 (P5): Reduced Stimulation

Reduced Stimulation, such as white walls or empty spaces, help the mind to relax and lose focus—often described as daydreaming. The brain switches frequently between two modes: the focused-mode and the defused-mode of thinking (Immordino-Yang, Christodoulou, & Singh, 2012; Moussa, Steen, Laurienti, & Hayasaka, 2012; Oakley, 2014; Raichle & Snyder, 2007). The focused mode (also called highly attentive state) is "a direct approach to solving problems using rational, sequential, analytical approaches" (Oakley, 2014, p. 12) mostly related to the prefrontal cortex. In the defused mode (also called resting state network or default-mode network) the mind wanders and connects different areas of the brain in a more relaxed manner (Oakley, 2014). The focused mode and defused mode are similar to the concepts of vertical and lateral thinking of de Bono (2009). The defused mode is associated with higher creativity (especially with divergent thinking) (Takeuchi et al., 2012).

Although visual stimulation can act as a source of inspiration, the exact opposite can also have a positive influence on creativity. White walls or other white spaces facilitate daydreaming and invite people to project their own ideas into it.

I had this picture frame from my grandmother. I left it white and I really like looking at it, I don't look at the frame, I look at the white space in the middle and I project the ideas into it. (EDU-3)

I prefer to have a white space, a white canvas, where I can spread out my thoughts, [...] if you would fill everything with inspirational material, that would have to be removed later to leave empty space for the next one [translated by author] (EDU-1)

However, McCoy and Evans (2002) demonstrated that spatial complexity influences creative performance positively. In this context, spatial complexity refers to complex environments, both in terms of how the space is organized and in terms of decoration. Decorative elements include personalization of the space and other objects, such as lamps or artwork. Their own results corroborate with Amabile's (1990) findings, which indicate that complex and provocative spaces trigger creativity. As this is partly in contradiction to the insights formulated by the experts, this proposition needs further investigation.

Proposition 6 (P6): Tactile, Olfactory, and Acoustic Stimuli

Besides visual stimuli, also other senses can be stimulated, which can have an influence on creativity, such as sound, smells, or tactility.

McCoy and Evans (2002) mention that complexity and variation—within the realm of materials—lead to high creative potential. They showed the importance of materials use in creativity. Natural materials, such as wood, were considered important to creativity. Kudrowitz et al. (2014) draw parallels between creative processes and cooking. Mehta et al. (2012, p. 785) suggest that "a moderate (vs. low) level of ambient noise is likely to induce processing disfluency or processing difficulty, which activates abstract cognition and consequently enhances creative performance". Hence, it can be argued that such stimuli are positive for creativity as long as they occur in a moderate degree.

> *I think materials are hugely important, I'm a very tactile person. And I think in terms of representing and promoting creativity, I think material surroundings are very important. It's visually stimulating. (EDU-2)*

> *Cooking is hugely creative, if I had to redesign the curriculum I would make cooking part of all creative curriculums, […] cooking would be key because there is so much to it: in terms of choices, colours, taste, textures, process, cooperation, the whole thing a creative process that is really similar to everything else. Creating a dish is like creating a company. (EDU-2)*

Proposition 7 (P7): Making Spaces

Making Spaces, such as workshops, are a central spatial element of every design school. However, the importance of manual prototyping for creativity could be even further facilitated by establishing tinker desks in each classroom or by providing prototyping materials at hand.

> *Somehow, you think differently when you touch things or when you try to build. You really come up with ideas that you cannot have come up by sketching or by looking out the window. You think different when you're making. (EDU-3)*

> *Yes, changing position of work is part of this definitely. […] I do believe that our brain works very well when we switch in between different thoughts like using your hands or your body doing something physically and using just your mind, so to speak, writing something or drawing then of course you use your hands still, but it's in less extent than building something or doing something physically. This interplay in between activities is quite important. (ARCH-2)*

Youmans (2011) investigated the influence of prototyping and material use in relation to fixation. Although he did not necessarily relate it to creativity, one can argue that if fixation is reduced when working with physical materials, then prototyping can potentially support creativity. Fonseca et al. (2009) established a connection between prototyping and creativity, within the domain of Human Computer Interaction in a Computer Engineering course.

Proposition 8 (P8): Open View

An open view outside a window into nature or an urban environment can have a positive effect on creativity and inspiration. The expansion of the mind into the outside world could facilitate the incubation effect. Moreover, views across rooms can also provide visual stimuli and foster social interaction.

> *if I'm trying to write here and I'm trying to look for a creative idea, I always look outside the window. (EDU-3)*

McCoy and Evans (2002) suggest that looking into a nature environment would foster creativity. On the other hand, Farley and Veitch (2001) could not confirm this hypothesis in their studies. Students in windowless rooms showed the same creative performance as in rooms with a view. However, participants of their study confirmed a higher level of wellbeing when performing in rooms that provided a window view.

Proposition 9 (P9): Movement and Bodily Activity

Movement, either actively (e.g. when walking or exercising) or passively (e.g. when sitting in a train or looking outside a window onto a busy street) can trigger a creative mood up to the sudden appearance of an idea (illumination). This can be explained by the relaxation state of the mind in which the mind wanders and connects different areas of the brain in more relaxed manners (Oakley, 2014), (refer also to Proposition 5—Reduced Stimulation). This sort of daydreaming could be facilitated through the space, for example by providing transitions spaces that require walking between buildings to get from A to B, or by providing some movement outside the windows. That way the space can facilitate the incubation phase.

> *I feel very much creative when I'm moving in the space, for example my best ideas I have when I'm walking or when I'm inside a car. Somehow movement for me triggers me a lot. (EDU-3)*

> *I cannot be creative without exercising two times a week [translated by author] (DES-1)*

> *Personally I think you learn, the more you move the more you learn. There is a connection between your physical activity and your mind work, so to speak. There was always this old idea of when you walk you think very well and you discuss very well when you walk. I don't know if it's fixed to everyone but I can sense that importance of physical activity while thinking or doing some intellectual work. (ARCH-2)*

Oppezzo and Schwartz (2014) experimentally demonstrate that walking boosts creative ideation. Kim (2015) conducted experiments in which participants had to squeeze a stress ball, which was either soft and malleable or hard. When participants got the soft one, the physical activity led to divergent ideas (in terms of originality and flexibility), while squeezing a hard ball led to convergent solutions (only one correct answer). Also, Gondola

(1986), Steinberg et al. (1997), and Colzato et al. (2013) provide evidences that physical exercise has a positive effect on creative performance.

Space could facilitate this by providing infrastructure for exercising, moveable (swivel) chairs, or furniture that allows or enforces different work positions. Also the view to a moving or busy exterior can facilitate a similar purpose.

Proposition 10 (P10): Playful and Experimental Atmosphere

Creating a playful atmosphere can have several positive effects on creativity: it stimulates experimentation and risk-taking, which facilitates flexibility of ideation. At the same time fun and games support the incubation phase. And finally, trial-and-error and failure are encouraged, which facilitate validation of ideas.

> *I hope that it expresses this freedom of unfolding yourself like feeling like here I'm allowed to do my studies the way I believe is interesting and not saying, "Oh you should design this way." or it should have this generosity towards each individual that they feel that they can develop in their own direction. (ARCH-2)*

> *A design school needs to have a protected space, a safe space in which you can act as you want, say what you want, design what you want, and where you do not feel embarrassed. Criticism from others helps connecting the dots and establish associations [translated by author]. (ARCH-1)*

For example, Berretta and Privette (1990) studied the influence of play on creative performance and were able to confirm an outcome of significantly greater creative thinking skills in children that practiced flexible play. Also Lieberman (2014, p. 30) suggests that the concept of play can instigate creativity by increasing spontaneity and flexibility, and support divergent thinking.

Proposition 11 (P11): Creative Labelling

Sometimes, just calling a space a 'creative space' or an 'innovation lab' can put someone into a mood receptive for creativity. Also the historic atmosphere of creative surroundings seems to have a similar effect. People tend to mimic the historic role models from art and design that might still be virtually present in their surroundings.

> *Well, the fact that Parsons is down in the Village which has traditionally been the center of creativity in this city is really important. I mean Jackson Pollock lived a block from here. The whole movement, abstract movement, they all lived here. (EDU-2)*

> *And of course there is the "Innovation Lab", and it [just the name] worked—it spread really fast like everybody was talking about it. Suddenly, everybody wanted to use it […]. But now, all of a sudden, everything is about innovation. Yeah. (EDU-3)*

The labelling of a space as specifically designated for creative activities can either result in people preparing and being motivated for this task (preparation) or even adapting the respective creative mindset (priming). This also includes not only the verbal naming of a space but also the design style of the space's interior. Bhagwatwar et al. (2013) studied

brainstorming performances in virtual environments. Their results indicated that people perform more creatively in spaces that are labelled to prime team members for improved creativity.

Proposition 12 (P12): Social Interaction

Several experts stressed the importance of social interaction with creative people to share ideas and feedback. In a way they suggested that the people are more important than the space. However, a good creative space can also facilitate and enforce those interactions.

> *I mean, I worked in circular offices, I worked in square offices, I worked in dark offices, light offices, sometimes we'd be sitting in the end of the room or sitting at the center of the room and I wonder that what triggers my creativity especially on spaces is I have to say it's not the space but it's the people inside. I see the people as a trigger of thinking. (EDU-3)*

> *All innovations basically emerge in the smoking corners, these informal spaces where everybody passes by and conversations come up [translated by author] (EDU-1)*

McCoy and Evans (2002) have identified that spaces that promote social interaction have a positive impact on creativity. This proposition is also supported by Amabile (1983), Zuo et al. (2010), Shaw (2010), and Le Dantec (2010). Space can facilitate social interaction through several means, such as strategic positioning of meeting points (e.g. copy machines), lounge furniture, or transparent walls, to name just a few examples.

Summary

Figure 2 illustrates the main propositions as a set of causal graphs including the involved variables. The expected impact is illustrated by an arrow, labelled with a plus sign (+) if the impact is positive (increasing), or labelled with a minus sign (–) if the impact is negative (decreasing). The 12 propositions and related evidences are also summarized in Table 3.

Table 3 Summary of Evidences for the 13 Propositions.

P#	Proposition	Supporting Interview	Supporting Literature	Contradicting Interview	Contradicting Literature
P1	*Surprising Space*	ARCH-2 EDU-3	Filipowicz , Grace and Maher (2015)	EDU-3	
P2	*Space as a Platform for Ideas*	DES-2 EDU-2 EDU-3 ARCH-1 ARCH-2 ARCH-3	Fischer et al. (2005)		
P3	*Creative Chaos*	EDU-2 EDU-3 ARCH-1	Clark (2007), Zausner (1996)	EDU-2 ARCH-1	Clark (2007)
P4	*Visual Stimuli*	EDU-1 EDU-2	Goldschmidt and Smolkov		

P#	Proposition	Supporting Interview	Supporting Literature	Contradicting Interview	Contradicting Literature
		EDU-3	(2006), Goldschmidt (2003), McCoy and Evans (2002),		
P5	*Reduced Stimulation*	EDU-1 EDU-3 ARCH-1 ARCH-3	Takeuchi et al. (2012), Oakley (2014)		McCoy and Evans (2002), Amabile (1990), Goldschmidt and Smolkov (2006),
P6	*Tactile, Olfactory, and Acoustic Stimuli*	EDU-2 ARCH-2	McCoy and Evans (2002), Mehta et al. (2012)		
P7	*Making Spaces*	EDU-1 EDU-3 ARCH-2	Fonseca et al. (2009), Youmans (2011)		
P8	*Open Views*	EDU-3 ARCH-2 ARCH-3	McCoy and Evans (2002)		Farley and Veitch (2001)
P9	*Bodily Activity + Movement*	DES-1 DES-2 ARCH-2 ARCH-3 EDU-3	Oppezzo and Schwartz (2014), Gondola (1986), Steinberg et al. (1997), Colzato et al. (2013), Kim (2015)		
P10	*Playful, Experimental Atmosphere*	EDU-3 ARCH-1 ARCH-2 ARCH-3	Lieberman (2014), Berretta and Privette (1990)		
P11	*Creative Labelling*	EDU-2 EDU-3 DES-2 ARCH-1 ARCH-3	Bhagwatwar et al. (2013)		
P12	*Social Interaction*	EDU-1 EDU-2	McCoy and Evans (2002),		

P#	Proposition	Supporting Interview	Supporting Literature	Contradicting Interview	Contradicting Literature
		EDU-3 ARCH-1	Zuo et al. (2010), Shaw (2010), Le Dantec (2010), Amabile (1983)		

Conclusions

This paper presents a collection of propositions that form a preliminary theory of the spatial impact on creativity in design educational contexts. The propositions are developed based on eight expert interviews and supported by relevant literature.

The work presented in this paper is considered a starting point for further research. Further literature searches and studies are needed for those aspects where no supporting or contradicting literature was found (indicated as empty cells in the respective tables). Of particular interest are also those aspects that have both, supporting as well as contradicting evidences. Here, further research is needed to clarify these questions.

Although there is a large body of complementing results there are also several conflicting aspects, what in fact means: When changing one spatial aspect to gain positive influence on creativity this might have a negative impact on another aspect. Solving such conflicts will be the focus of our future work as well.

The scope of this study is on experts of design educational spaces, only. We did not include the perspective of students in this paper. However, in previous work we conducted an extensive study with students of two educational institutions that lead to the development of the typology presented in Figure 1 (Thoring, Luippold, & Mueller, 2012b; Thoring et al., 2012a).

As a conclusion, we argue that the results presented in this paper are of high relevance for design education, as they will contribute to a better understanding of the influence of spatial design aspects on creativity of design students. Although the main aim of this paper is to provide insights that can support improving the learning environments of design students, the presented propositions might also be useful to practitioners in any area that deals with creativity and innovation, as well as to educators from other disciplines, who want to create inspiring environments for students and teachers.

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