# Finding and Implementing Patterns for Creative Spaces

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*Abstract*— **Ideation and design thinking are important skills that should be acquired in higher education to prepare students for modern work requirements. We have implemented several workspaces at our university that foster creative work by providing tools, materials and an inspiring atmosphere. To make the spaces fit to the goals of creative thinking we have identified good practices as design patterns. The patterns are based on existing solutions and have led and justified our design decisions. In this article we will discuss the benefits of the pattern approach to find meaningful solutions. The mining process will be outlined and some of the resulting patterns are presented. Finally, we will reflect how the patterns have helped us to achieve our goals. The patterns can be used by other universities and companies to create similar spaces as each pattern describes the solution in a generative way.**

***Keywords-design patterns; innovation; creative space***

## I. Introduction

We planned to create several spaces for innovate work at our campus. The motivation was to increase the creative potential in student projects. Thus, the space should be enabling in a sense that it provides all the tools for design thinking, including ideation tools, building materials for rapid prototyping, ways to investigate the problem domain and test ideas as they are developed. The appropriate methods should be supported by both classic and digital tools. Moreover, students should learn the methods while they are using them. Creative spaces should be both enabling and educating. In addition, creative spaces should be efficient, i.e., no setup time, no boring meetings where only a few dominant persons speak, and low thresholds to use tools and technology that make the creative process more effective. The rooms should also be exciting and help students to experience their university as a place of innovation. The spaces should promote project-based and skill-driven learning, establishing a result-oriented "maker culture". Our goal is to create four different spaces, each addressing different activities: an innovation space for generating ideas, a thinking space for retreat and reflection, a maker space for prototyping and testing, and a planning space for managing projects. The need for different spaces for the various activities is based on the pattern Ecosystem of Workspaces [1], see Figure 1, and the design principles for creative spaces [2].

Our means to get there is to do identify existing patterns and develop new patterns for creative space. We use the design pattern approach to generalize and analyze existing good solutions.

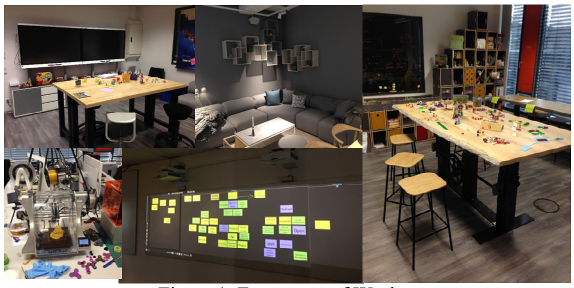

Figure 1. Ecosystem of Workspaces

The rest of this paper is organized as follows. Section II discusses related work, including the impact of creative space for university development, existing design frameworks and the design pattern approach. Section III describes the mining process along with example patterns. Section IV reflects on the lessons learnt and how one can test the patterns both qualitatively and quantitatively. Section V draws conclusions and outlines future work.

## II. Related Work

In this section we explore the design of creative spaces in universities and compare frameworks and design patterns as planning tools.

### A. Impact of creative space for university development

The importance of interior design in academic teaching contexts has been highlighted recently. The Horizon Report [3] has picked up this topic in recent years, again and again, under the themes "Maker Space," "Bring your own device," "Flipped Classroom," "Internet of Things," "Wearables," and "Redesigning learning spaces". An approach to these concepts should be of strategic importance. A commission of experts of the "Hochschulforum Digitalisierung" (Panel for digitization in higher education) concludes that "maker spaces and creative spaces" and "digital collaboration tools" are among the key technologies of a digital university.

### B. Existing room concepts and design frameworks

There are several frameworks that deal with the design of innovative spaces and spaces that blend classic and digital tools. For example, the TACIT framework is derived directly from a blended space approach [4] by identifying

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key elements, such as territoriality, awareness, control and interaction. Another framework for understanding the role of the physical environment in innovation focusses on the related goals of such spaces [5]. The framework distinguishes between strategic and symbolic goals, innovation efficiency and effectivity, enhanced teamwork, stronger involvement of stakeholders and expanding entrepreneurial skills on a general level. It operationalizes these objectives and differentiates between factors for the planning of the space as well as factors for the evaluation of the degree of attainment. There is also a conceptual framework for spaces to foster and sustain innovation that compares the criteria of different frameworks [6]. All of these frameworks have in common that they name important principles, criteria and directives for planning and testing. However, when it comes to the concrete design of a new space, they remain very general and often too abstract. Therefore, in our view, the design pattern approach of Alexander et al. [7][8] seems to be a better alternative. It keeps the general reasoning but provides tangible and holistic advice to implement solutions.

### *C. Design Patterns*

The idea to capture balanced patterns of good design has its origin in the field of architecture. Christopher Alexander wanted to create a language which helps ordinary people to participate and express their wishes and demands in the design of towns, buildings and constructions [7][8]. The approach was adapted in many other fields, especially in the domains of software design [9] and software education (Pedagogical Pattern Project). There have been several patterns on education and e-learning [10]-[12]. According to Alexander, "each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice [8].“ As such, patterns capture the essence of recurrent good solutions. They describe both the solution form and the process to generate this form. Likewise, "an e-learning pattern captures the regularities of good practices in order to reuse the proven methods, scenarios and content forms in new contexts addressing new design tasks. The core idea is to not reinvent the wheel but to preserve what has been successful in the past. Beside the explicit description of good (successful) pedagogical methods, tools, media formats, resources, and scenarios design patterns reason about the adequate use of such solutions [13]." Patterns clearly state the design problem and design solution in a structured way and provide a "comprehensive set of design ideas [14]." They can be used to discuss different aspects of design expertise and provide a lingua franca for joint course design [15].

The reflective analysis of patterns requires that a description of patterns discusses how and why a solution works. A form or intervention is neither good nor bad in itself but produces different consequences depending on the context. Patterns are never seen in isolation but capture the environments in which they work, often by relating to other patterns. Patterns can describe specific actions to overcome existing seams. But more important, they explicitly state what the problem of the existing seam is. Problems are discussed by analyzing conflicting forces from different perspectives, i.e., social, technological, political, and economical factors. This integrates the views and requirements from different stakeholders and makes the relations between different levels explicit. For example, choosing a specific social media strategy can open new options as well as limiting the learner's choice. The curriculum can drive decisions on both the level of the learning organization as well as the individual teacher's/learner's behavior. Individual interests can conflict with organizational strategies but also support new ways of collaboration. There are already some pattern languages about creative collaboration, presentation and learning [16].

## III. PATTERNS FOR CREATIVE SPACE

We will first describe the pattern mining process. Then, we will discuss the identified pattern categories and present some examples.

### *A. Pattern mining*

Identifying and documenting design patterns is called pattern mining. There are different approaches for pattern mining [17]. The approach taken here is a typical mix of methods of inductive and deductive research:

- Deriving requirements and factors from frameworks
- Analysis of existing good practices for interior design
- Visits to tradeshows and exhibitions, browsing product brochures, explore existing rooms
- Testing of classic and digital tools
- Participatory design sessions with later users of the space (students, docents)
- Evaluation of different design options with mockups

In the process of identifying the general forms of the patterns, the findings from general frameworks can be considered as the driving factors. Moreover, we found recurring structures in case studies of existing facilities: i-Land [18], ICE [19], and iRoom [20]. Furthermore, numerous analog tools (e.g., methods cards, innovation games) and digital tools (e.g., iPads with pen, touch screens, tabletops) were tested in the laboratory or at exhibitions. Various design options for the room were played with, for example using mockups to explore the optimal size for a center table that should be used as a "stage" for the creative process. Various pattern candidates have emerged from this analysis. Pattern candidates that we can support empirically by several examples and that we can explain plausibly using establishes theories, have been selected to plan the rooms.

### *B. Pattern categories*

The identified patterns can be characterized and clustered into categories of different problem groups: work materials and tools, atmosphere, session management, navigation and blended interaction. The first category is about the materials and tools that should be available in creative spaces. Since we cannot always predict which materials will be needed in a

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creative session, an abundance of materials should be available to give users freedom of choice. Boxes with work materials are frequently found in design thinking contexts. The room should provide several THOUGHT TRIGGERS that provide impulses for ideas. Examples are random images, story cubes, and stimulus words both in physical and in digital form. For visualization, we provide A BUNCH OF PENS AND PAPERS as well as digital tablets and interactive whiteboards. CURIOUS THINGS are unusual objects to stimulate lateral thinking. Such objects can be spread around or hidden as a surprise element in containers (SURPRISE). Furthermore, various project templates (WORK TEMPLATES, e.g., Business Model Canvas) should be provided for analytical processes. The filled out templates can be digitized automatically and possibly trigger other actions (TEMPLATE TO ACTION), e.g., automatic sorting into various digital lists (such as pros and cons), or using drawings within other programs (games, living mockups). Figure 2 shows some example materials and tools.

Figure 2. Materials and tools

The atmosphere of the room also plays a special role in creative work. For this reason, we have identified many patterns in the physical space, such as ambience, plants, high-quality furniture, bar stools and workbenches, sofas, pictures and sound. QUALITY FURNITURE suggest to use high quality and extraordinary furniture. In a valuable environment, people feel more valued. The space should support different MOODS with illumination and sound. We also need a PLACE OF RETREAT, where participants can relax and let the mind wander (phase of incubation). To avoid distractions, the room should have NO CABLES, be SOUNDPROOF BY CHOICE and have only soft angles.

Session management requires solution patterns to save sessions, restore them and take them into other (physical) rooms without seams, i.e., the transfer is automatically supported by cloud based solutions that can show the same content in different rooms. A backup functionality must be available for data security. To retrieve lost data back, restore functionality must be given. The rollback enables the applications and systems to return to a prior state. This is often a standard feature in online tools such as Google Docs or Wikipedia. Nevertheless, we consider the explicit documentation to be important as a model for the design of new tools. ROOM RESET refers to a quick way to reset all systems and return them to their original state. This solution is very important to avoid revealing work results to the wrong eyes, i.e., if the next work group enters the room all prior writings should disappear. Room reset features are often found in software systems for interactive whiteboards (such as SMART Boards, Microsoft Surface Hub). If a group of users returns to the room a week or a month later, they should continue to work where they had stopped. Hence, it must be possible to access a history to prior results. All devices in the room are restored to this state and provide the same set-up of the last event (ACCESS TO OLD SESSIONS). Since there are several independent innovation rooms, we need a way to take the complete session to another room. This is also relevant for break-out sessions. This leads to the pattern CROSS-ROOM INTERACTION.

The navigation space must also be considered in a creative room concept. There are different solutions that help users to find orientation inside the room - for example, some analogue and digital tools are self-explanatory. However, in a space that offers many possibilities, not everything can be grasped at first sight or is intuitively usable. For orientation and guidance, we can use TANGIBLE INSTRUCTIONS such as menu cards with brief instructions, overview maps or “cookbooks” that provide step-by-step guidance and highlight which building blocks are useful. Using QR codes, these physical elements can in turn call up video instructions for smartphones or wall displays. Icons of digital user interfaces should be fully self-explanatory. Users should see at first glance which action is trigged if a button is pressed. Objects in the room need to be placed in such a way that users are encouraged to use them. For example, Lego bricks and sticky notes should not be hidden in a cabinet. They should be accessible right away and offer a high affordance.

Perhaps the most interesting category is Blended Interaction, as it is concerned with solutions that enable a seamless integration of the physical and digital world. The pattern PHYSICAL TO DIGITAL regards physical actions and artefacts that can be digitized immediately. When a user sketches with a pencil on a digital surface or a sheet of paper, it is to be digitized immediately by a touch-sensitive surface or a camera. The complementary pattern is DIGITAL TO REAL. Objects created in the digital space should not remain only digital but are brought in to the real world. Examples are projections onto physical objects, walls or on the floor, the printing with photo or 3D printers, as well as the controlling of robots or Raspberry Pi modules. Moreover, physical objects are used as simple triggers for interaction between the digital and physical world (PHYSICAL OBJECTS TRIGGER ACTIONS). An example is digitizing a sketch by pressing a physical button. Rooms that contain several digital devices need some means to connect them and share data (DEVICE ORCHESTRATION). Examples are: sending brainstorming items from smartphones to interactive walls, sketch characters or labyrinths on tablets and use them on game arcades, or selecting the content for large displays using small interactive tablets. One step further, we can orchestrate the connected devices to one large unit (COUPLED DEVICES). This way several independent devices can be connected to form a larger contiguous workspace. Examples are: dual projections of interactive whiteboards controlled by one computer, small info screens that connect to a large info screen, interconnected wall screens, tablets on a coffee table forming a temporary interactive tabletop.

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### C. Pattern examples

This section contains two detailed pattern examples and three short pattern overviews as additional examples.

#### 1) Hybrid Space (Pattern)

The dichotomy of digital and non-digital artefacts is resolved in a hybrid space by seamlessly bridging different types of artifacts, making digital data touchable and graspable, enhancing physical objects with digital information and digitizing physical objects.

Context: We live in the real physical world, digital and connected devices are ubiquitous. Very often both worlds exist in their own space, and are only superficially interrelated. Things we can sense (feel, touch, see, hear, etc.) are more meaningful to us. We like to tinker with real things. Very often we either work in the physical world only or in the digital world only.

Problem: Working in the physical world limits the way of sharing and manipulating objects – the digital has much more to offer. However, the digital world limits the richness of interactions to a predefined set. Moreover, the digital world lacks the embodiment of actions, such as playing and tinkering with objects physically with your hands (or other body parts) and arranging them spatially in a natural way.

Forces: Ease of use. Interaction with objects is easier when they are real and tangible. Digital objects can be easily manipulated, edited, shared and distributed.

Representations. Objects of the real world often can be represented as virtual objects (for example a sticky-note can be a real piece of paper or a virtual object). Physical object of our world can be augmented with additional information and functions using digital tools. The mode of optimal representation depends on what you want to do with the object. Do you want to touch it? Move it in real physical space? Or do you want to share it across remote locations and work on it with remote participants? Very often both is needed.

Solution: Therefore, merge both physical and digital space into one hybrid space where real world objects can be digitized and represented in virtual space, and the digital space can be brought into the real world using tangible objects and devices.

Both the physical and digital worlds have their own strengths and weaknesses. To empower the best of both we need to enrich both worlds with each other seamlessly. Every smartphone is capable of digitizing physical objects by simply making a photo. Special apps can support the extraction of meaningful information: identifying single sticky notes, mapping whiteboards to images, recognizing objects and gestures. Document cameras can quickly scan 2D documents and 3D objects and send them to digital work spaces. Objects of the real world can also trigger the display of meaningful digital information. For example, a QR code or a specific layout on book pages or playing cards can start-up programs or blend in additional information. This additional information can appear on the smartphone screen (augmented reality) or on additional screens. On the other hand, the information of the digital world can be projected into the real world. Each smartphone becomes a window to the digital world. Projectors can display information on walls and even on objects. Physical objects can be enriched with small displays or other outputs (audio, motion) based on digital processes. Objects in the physical world are always at hand (you don't have to turn on a computer), and many actions are more natural in the real world. For example, feeling the surface and weight of objects gives you direct clues how to hand and work with them. Setting up new arrangements is fast, straight-forward and requires no training. Writing and drawing on paper still provides a richer experience than most digital tools offer. The interaction of surface properties, pen type, layers of color etc. is still a richer experience.

You may expect: The real and digital worlds merge. Benefits of the digital world are mapped to real world objects. Real world objects can be represented seamlessly in the digital world, thus making sharing and manipulation easier. Information can be mapped to real world objects, allowing rich learning experiences. Tinkering with objects – real and digital – is encouraged and creative learning is more likely to happen.

However: To make the transfer between both worlds seamless, a lot of hardware and software is needed. Thus, the experience is often bound to special rooms. It requires a lot of knowledge about methods and technology to unleash the full potential. While playing with things is a good and encouraging experience, it can also lead to using the technology for the sake of using technology.

Examples: Document cameras to scan objects and show them on an interactive whiteboard, apps to photograph sticky notes and bring them to the digital world, 3D printers to make virtual objects tangible, digital twins (computerized companions of physical assets), or putting cards on a scanner and map the content to virtual objects.

#### 2) Orchestrate digital devices (Pattern)

Context: Each device has different strengths. If you switch between the appropriate tools you can use the benefits of each of them. Some are good for drawing, others for showing or interacting. In a room with several devices, users should always choose the tool that fits best to the task. Since tasks often lead to different activities, users may want to switch digital tools seamlessly.

Problem: Using different tools in isolation may offer the best of each world. However, it does not offer new ways of collaboration. It limits collaboration, because switching from one tool to another interrupts the flow of working and thinking.

Forces: There are two types of devices, the ones which are used individually and the ones that are used together. Devices offer different functions, haptic characteristics, etc. Tools which are ideal for inputs aren't equally ideal for outputs and the other way around. At the one hand a large display is very hard to control by touch or even with the mouse pointer, at the other hand a small display is not suitable or appropriate to present information to groups of people. Each device has its own affordances. Which device is the best, may change in the work process. Then it's

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important to switch between the devices seamlessly without losing the work results that have been created to that point.

Solution: Orchestrate digital devices in such a way that you can seamlessly use and transfer objects between them. That way users can freely choose where to display, create, edit and use objects. This choice can depend on individual preferences or different modes of usage.

You can connect different devices using the patterns for ad-hoc connection. To share data between devices you have to run them either in a local WIFI or connect them via a cloud service. The devices need a shared (and protected) data storage, e.g., a place where one device can upload files such as images, and another device can download the files. To notify other devices about new available data, the devices need to observe this shared file space or listen to events. One implementation option is a central event server that distributes events and notification. One tool can upload a file and notify the event server. For example, someone could draw a picture on an interactive whiteboard and save it to a specific location on the file system. A local process observes the folder and uploads the drawing. It also notifies other devices that a new drawing is available. Tools that are interested in this kind of data can automatically download the file and use it for their own purposes (e.g., use the drawing as a sprite in a game or a new screen in app mock-up).

You may expect: Open interfaces enable device orchestration and inter-device communication.

However: The devices have to use the same application or a compatible software to be able to orchestrate. Not all hardware and software vendors provide open APIs for seamless sharing, and often a hack is needed.

Examples: Users draw app mock-ups on a large digital whiteboard that allows to edit several screens at the same time. The sketched screens can be compiled to a Living Mockup that runs on tablets or smartphones instantly. Tablets can be used as interactive wall pictures. They can offer different actions or methods. Users choose a specific method on the wall tablet and large working templates are open on a digital whiteboard automatically. Users draw on a tablet and the drawn elements become game sprites on an arcade machine instantly.

#### 3) *Thought Triggers (Pattern Overview)*

Problem: You need a push into a new direction.

Forces: We tend to step into the same direction. We might be preoccupied and biased by your known solutions. Old thought patterns need to be disrupted. There is a need for external source to disrupt your thought patterns.

Solution: Use textual or visual stimulus as thought triggers: Ask different questions, take in a new perspective, or restructure your problem.

#### 4) *Sticky Notes (Pattern Overview)*

Problem: High effort to change structures makes exploration less likely.

Forces: Add ideas quickly, parallel. Move categories and concepts. Spatial arrangement implies meaning. Explore alternatives. Easy setup, use everywhere.

Solution: Use sticky-notes to write down your ideas.

This pattern description is a good example for a solution that is well known. However, the description makes the underlying problem and benefits explicit. It does not simply recommend sticky notes but explains why this tool works.

#### 5) *Playfulness (Pattern Overview)*

Problem: Your thoughts are constrained by conventions and fear of breaking rules.

Forces: Positive feelings make you more creative and productive. Be less serious. Turn expectation upside down. Seek ambiguity, connect unrelated concepts, draw new analogies. Get rid of order, rules and assumptions. Allow exploration without consequences.

Solution: Put yourself and your team into a mood of fun and playfulness.

## IV. Lessons Learnt in Using the Patterns

This section discusses how design patterns have helped to plan, create and use creative spaces. We also draw conclusions for the use of patterns in general.

### *A. Understanding of forces and consequences*

During the planning process, the patterns helped us to check concrete technologies with regard to the properties we had required. The lower abstraction layer created by patterns helps to make concrete implementation decisions and to justify them. By discussing the consequences of a design pattern, not only the positive effects but also possible limitations become transparent. For example, there are some patterns that may have a negative impact on users' sense of privacy, such as automatic speech analysis and cameras in the room. Through the explicit naming of subsequent problems it is possible to search for further solutions.

### *B. Justification for design decisions*

Patterns also help to convey the elements of the space better to address other stakeholders. The forces provide solid justifications for design decisions – even for unconventional elements. For example, the use of Lego bricks and innovation card games may confuse some people. The patterns, however, explain what has driven us to use these elements: their combinatory qualities to explore, the playfulness to challenge assumptions, and their inspiring potential.

### *C. Manage complexity*

Furthermore, the patterns have helped break up a complex spatial composition into individual components that can be considered nearly independent while still fitting into the overall concept. The harmonious interaction is ensured by cross-references between the patterns.

### *D. Identification of deficits*

To some extent design patterns also reveal technological deficits. The design pattern DEVICE ORCHESTRATION is indeed not an utopia but derived empirically from concrete examples of linking devices. Yet the interplay of all digital devices in the room is currently not fully implemented due to missing protocols and technical interfaces. Nevertheless, DEVICE ORCHESTRATION remains a valid solution. It is just that the implementation is more complex and cannot be implemented for all devices in the short term. For many devices and systems, it is a missing solution. Similar constraints as well as unexpected potentials have been uncovered by identifying the patterns.

### E. *Empirical support*

Patterns that are not sufficiently empirically confirmed yet are considered as proto-patterns, that is proposals for a better future. However, most of the identified patterns are based on existing space solutions and usage concepts. Nevertheless, only future will show whether the rooms are accepted and used as we intended. The actual use will thus lead to a confirmation or falsification of the patterns inductively determined. So far we have observed that the rooms are highly frequented and students ask for more of such facilities. At the moment we are running a quantitative survey about the user experience. A questionnaire covers the activities, satisfaction and outcomes of a session. We are also measuring the use of tools and their impact on the design results qualitatively. Since most design projects require written reports about the process, we are able to analyze how the room was used. Moreover, many design sessions are led by facilitators who can observe how students explore and use the room. Based on these findings, the patterns will be refined and adapted.

## V. Conclusions and Future Work

The identified design patterns have been implemented to a large extent for the innovation rooms we have designed. They have proved to be a very good planning tool. The design patterns are based on the observation, analysis and experimentation with existing solutions. They do not replace the mentioned frameworks, but make them a step more concrete and thus empirically verifiable. The frameworks also provided a theoretical foundation for the establishment of the solutions. Our next goal is to put all our patterns into an action-oriented booklet and a deck of cards. So, through experience it will be easier to close the gap of missing system components. New transformation projects will benefit, respectively. The patterns help not only in the concrete design process but provide arguments why certain interventions for a more creative work environment of the students are conducive.

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