# Blended Interaction in innovation spaces

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Blended spaces mix different spaces (e.g. physical and digital, social and conceptual) into one coherent whole. The blend is more than the sum of its part because new properties emerge. In a blended space, physical and digital activities overlap. A blended space consists of several physical devices that connect to the digital world (e.g. digital whiteboards, interactive tablets, smartphones, game arcades etc.). We have developed a room for design thinking - an innovation space - that enables interaction with objects from the physical and digital worlds, from the conceptual and the actual worlds. This paper describes patterns that enable blended interaction within such spaces.

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## 1. INTRODUCTION

Blended spaces are spaces that mix and overlap different spaces, including physical, digital, information, conceptual and social spaces (Benyon, 2014). The goal is not to add the functions of each space but rather to create new spaces all together – not just the "best of both worlds" but "new worlds". The blended innovation space offers both digital and non-digital tools for design thinking, and makes the interplay of both types of tools and artefacts seamless. Examples include the mapping of digital artefacts onto physical artefacts or the immediate digitalization of sketches, 3D objects or sticky-notes. One goal of blended innovation spaces is to support design thinking activities, in particular the phases of ideation (getting new ideas) and prototyping (exploring idea implementations early). Design thinking has been developed and formalized at the Stanford School of Engineering (Lindberg, Noweski, & Meinel, 2009). Design thinking enables systematic innovation (Meinel & von Thienen, 2016). It is an iterative process that is user and customer centered, offering solutions to complex and wicked problems (Uebernickel et al., 2016). Wicked problems are hard to solve because their definition is incomplete, contradictory or hard to balance as any solution attempt introduces and uncovers new problem dimensions. The systematic approach blends both analytical and synthetic phases. Deep understanding, observation and research, integrating multiple points of view, and testing are mainly analytical tasks. Ideation, tinkering and prototyping are rather synthetic phases. Design thinking integrates diverse methods for creative thinking and innovation into a unified process that iterates through each of the following steps:

- Understand: Deep understanding of the problem domain, requirements and needs, target audience and stakeholders.
- Observation: Observation of users and customers. Quantitative and qualitative research of functions and processes of the problem domain, ethnographic methods to better understand the actual situation, participative design methods and co-creation.
- Point of View: Aggregation of research results and interpretation from different perspectives.
- Ideation: Generating new ideas with creativity methods and lateral thinking
- Prototyping: Rapid prototyping in early stages of the design process to make solutions visible and easy to communicate.
- Test: Test and evaluate solutions with real users.

An innovation space should provide tools, support methods and create an inspiring atmosphere to go each of these steps more effectively. Since tools are available in both the digital and physical world, we wanted to combine both worlds into a coherent experience. Thus, we wanted to blend different spaces. The approach of blending different spaces has been developed by Benyon (2014). It is rooted in Fauconnier and Turner's (2008) Blending Theory, assuming that the blending of different concepts creates new concepts. The theory originally addressed only language and semantics but is now used in creativity, music, history or mathematics (Turner, 2014). Blended Interaction Spaces (O'Hara, Kjeldskov & Paay, 2011) are blended areas that integrate interactive elements within physical spaces. There are several domains where blended spaces can be beneficial, including collaboration, education, tourism or museums (O'Keefe & Benyon, 2015). Blended spaces are used for interactive collaborative environments (Benyon & Mival, 2016).

## 2. DESIGNING AN INNOVATION ROOM

At the computer science department of TH Köln (University of Applied Sciences) we build on this approach to create a room that allows creative working and design thinking. The room will be equipped with digital and non-digital artefacts that should interact seamlessly. The room should increase the creative potential of student and industry projects. Moreover, we want to empirically test which methods work and which new methods need to be developed. Problems arise when users want to use all the tools together because many systems are proprietary and there are no simple ways to connect them. Therefore, we are planning new software and hardware tools to dissolve remaining seams between technologies and methods for creative thinking. The goal is to establish a "maker culture" where students (and other users of the room) switch to a "design thinking" mode as soon as they enter the room. Hence, the room needs to offer an abundance of inspirations and collaboration opportunities.

To achieve these goals we have analyzed existing room concepts, tested many software and hardware solutions, and developed our own concepts. The patterns we present in this paper are based on the following deductive and inductive mining methods:

- We derived requirements and forces from existing frameworks for collaboration rooms (Benyon & Mival, 2015; Moultrie et al., 2007; Bustamente, 2015)
- Analysis of good practice examples of innovation rooms (taking pictures and notes at other universities or companies; exploring books and magazines on office design)
- Visits to trade fairs, analysis of product brochures, visits to maker spaces
- Testing of digital and non-digital tools (e.g. real sticky notes and collaborative sticky note software, inspiration cards, random idea generators)
- Participative design sessions with potential users of the room (see fig. 1)
- Evaluation of design alternatives based on mock ups.

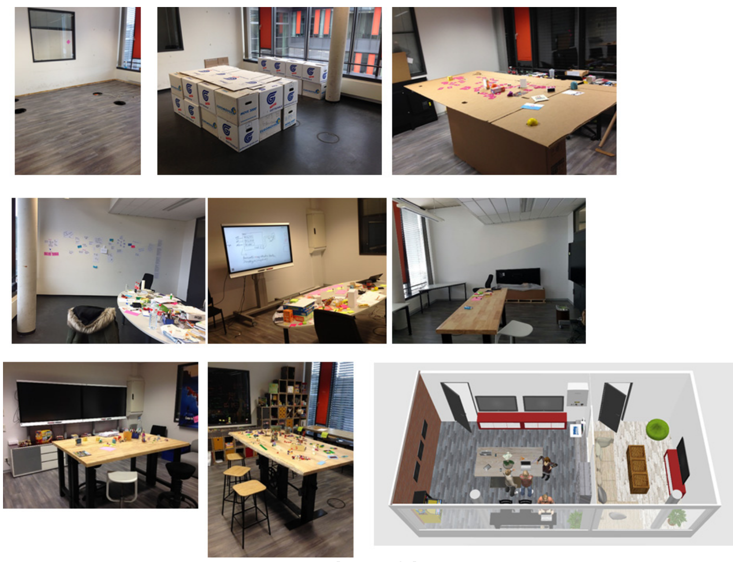

Fig 1. Mockups of the room.

We have not developed all patterns to full detail yet. However, the pattern sketches (or patlets) have helped us make design decisions on a more rationale base. We also learned that we had to neglect some ideas as we started the actual implementation. There are also some problems we have not resolved yet, such as full cross-device orchestration. However, we are experimenting with new solutions to fill the gaps eventually. The patterns have also helped a lot to justify design decisions. For example, the room has many playful elements, including card games (with thought triggers), Lego bricks (for prototyping), and even a game arcade (for serious innovation games). Because patterns explain WHY a solution has been chosen, the patterns helped to explain our decisions to others. Yes, the Lego bricks are fun. And theories on creative thinking suggest that people generate more ideas when they are in a fun and playful environment – because participants relax and are more willing to challenge assumptions.

The patterns presented in this paper are based on our research and practical experience in creating such a space. This includes planning and configuring the equipment, development of new apps and tools, and running design sessions in that space. This paper has two main audiences:

- Organizations that want to use digital media to enhance rooms for collaborative work
- Developers of apps and platforms for collaboration in real and virtual space

## 3. OVERVIEW OF THE LANGUAGE

We have used a full set of patterns to design our own room. We were able to express the whole room design (see fig. 2) with the patlets we had mined. Hence, we are confident that we have actually a language because the patterns enable designers to express new designs for innovation rooms.

Fig 2. The innovation room.

However, we have not yet described all patterns in detail, this paper is only the beginning. We clustered our patlets into different categories. Some of the patterns are quite small in their scope. Hence, there is a good chance, that they will be integrated into other pattern descriptions rather than describing them as individual patterns. Yet, each of the patterns is a solution on its own right and we can provide examples, name the context and forces that lead to the solution. To provide an overview, this section clusters our patlets into different categories.

### 3.1 Material

For design thinking it is very important to have different materials one can use and work with.
ABUNDANCE OF MATERIALS: Provide many different types of materials, let users chose the right material depending on the situation.
BUILDING MATERIALS: Provide materials that users can use for rapid prototyping: boxes, bricks, glue.
THOUGHT TRIGGERS: Provide materials that trigger thoughts, e.g. photos, questions, random words.
CURIOUS THINGS: Place some unexpected surprise elements in the room to make people think into very different directions. Examples: a bottle of butter beer, small toys.
A BUNCH OF PEN AND PAPER: Make it as easy as possible to write down an idea.
TEMPLATES TO WORK: Provide templates (such as business model canvas, SWOT analysis) to work with.
TEMPLATES TO ACTION: Provide automatic analysis / digitalization of templates (e.g. scan all items from a SWOT matrix, and put each item into the correct category automatically).
SURPRISE: Provide unexpected opportunities.
LIVING MOCK-UPS: Enable users to create mock-ups that work.

## 3.2 Atmosphere and Flair

It is important to set users into the right mood for design thinking. The room should be different than classic cubicles, class rooms or offices.
AMBIENCE / FURNITURE: Use high quality furniture that sets the right design spirit.
MOODS: Support different moods with illumination and sound
PLACE OF RETREAT: Have some space to relax, let the mind wander (phase of incubation)
PLANTS: Add organic and natural elements to the room
SOUND: Provide fast access to sound background (e.g. classic museum, coffee shop noise, ZEN sounds)
ILLUMINATION: Use light to set Moods and direct attention
SOUNDPROOF BY DECISION: Make sure no one is distracted by noises from neighboring rooms.
NO CABLES: Hide all cables.
QUALITY ENVIRONMENTS: Use high quality furniture and equipment to let users feel valuable.

## 3.3 Spatial Use

As we designed the room we discussed a lot how people would actually use the available space.
ALL SPACE IS ONE CREATIVE AREA: Allow users to use the full room for their collaborative work: all walls, all windows, everything.
PLACEMENT AREA: Provide enough space for users to put down their ideas, prototypes and artefacts.
DON'T BE SHY - USE EVERYTHING: Invite users to tinker with everything in the room
WINDOW BAR TABLE: Provide a bar table that offers a nice look out.
CENTRAL TABLE: Have one table at the center to collect all major information and results.
WALK AROUND: Let people move freely in space.
ADJUSTMENT OF HEIGHT: Support universal design to include all users.

## 3.4 Maps / Navigation

Innovation rooms are popping up in many organizations. Yet many of the methods, tools and techniques are new and people don't know how to use the room efficiently.
TANGIBLE INSTRUCTIONS: Provide instructions that are fun and tangible (such as a menu card with design methods).
VIDEO (INTERACTIVE) INSTRUCTIONS: Integrate on-the-fly video instructions to the room
ILLUMINATE: Use light (Projectors, LED, etc.) to point to specific tools.
INVITE ACTION (TOUCH-ME): Equipment should have a high affordance to interact with.
CHOOSE YOUR TOOL: Let users freely choose from a large set of different tools.
DEFAULT APPS: Provide important software tools on interactive whiteboards, screens and tablets.
FAST ACCESS: Start the most important apps and templates quickly. Do not lock sticky-notes into a cardboard but place them on the table.

## 3.5 Reaching Out

The innovation room is an island. But not an isolated island. Get ideas from the outside world and share them with others.
CONNECT TO THE WORLD: Provide plenty of opportunities to take inspirations from the outside world (such as using Instagram photos for inspiration).
WHAT'S UP? Let others know what's going on the in the room. Is it an innovation session? An idea review? About what?
CAPTURE THE MOMENT / PROCESS: Make instant pictures of work results and share them with the community.

## 3.6 Session Management

Working in an innovation room often involves several meeting sessions. People need to be able to take their work results with them, and bring materials in.
BACKUP – RECOVERY – ROLLBACK: Enable different configurations for the room, especially when experimental setups are run.

ROOM-RESET: Self-clean all digital devices by resetting their configuration and delete confidential work results.
ACCESS TO OLD SESSIONS: Save a session and restore all files and screen set ups in the next session.
CROSS-ROOM-INTERACTION: Take the work results from one room to the next. Collect results from break-out sessions in one room.
PHYSICAL TURN OFF OF RECORDING DEVICES (BIG BROTHER GOES BLIND): Add physical shutters to cameras and enable users to disconnect mics to have privacy by design.

## 3.7 Blended Interaction

The innovation space should enable a high degree of interaction and switching between digital and physical tools and artefacts should be seamless.
INSTANT CAPTURING is about bringing physical artefacts instantly into the digital world.
DIGITAL TO REAL is about making digital information visible or touchable in the real world.
HYBRID ANNOTATION is about sketching and writing on digital devices in order to annotate objects of the physical world.
CHARGING STATION is about providing energy to individual mobile devices.
SPEECH CONTROL is about using voice recognition to trigger actions in the digital world.
DEVICE ORCHESTRATION is about the seamless interplay of several digital device within one space.
BYOD is about integrating the individual device of participants.
COUPLED DEVICES is about connecting several devices to one larger unit
INSTANT CONNECTION is about simple and fast connection individual device
The seamless interaction of both physical and non-digital artefacts needs to be orchestrated. Several patterns can help to create a rich experience that allows users to blend the worlds.
The patterns INSTANT CAPTURING, DIGITAL TO REAL, HYBRID ANNOTATION, and SPEECH CONTROL will be presented in this paper. The patterns DEVICE ORCHESTRATION, COUPLED DEVICES and INSTANT CONNECTION are part of the paper “Patterns for cross device communication in a blended space for innovation”, submitted to EuroPLoP 2017 (Dubbert et al., 2017). The pattern BYOD is part of the paper “Hybrid Learning Spaces”, submitted to VikingPLoP 2017 (Kohls & Köppe, 2017).

# 4. INSTANT CAPTURING

Blending the real world into the digital world

## 4.1 Context

You are working with many physical materials – in a design room, your office or even outdoor. You have created good clusters of ideas, or some prototypes. Now you want to test something new, or move on to the next project.

## 4.2 Problem

Creative workspace is in continuous flux. Interim results get lost when a group alters their artefacts and concepts. When new groups use the workspace, it will be cleaned and previous work artefacts get wiped away.

## 4.3 Forces

*Cleaning.* Cleaning the physical work space may destroy work results for ever. Storing work results permanently and re-storing them later to continue the work is very difficult and in many cases impossible. Cleaning up means that all hard work gets lost. Sharing the process and results with others at other locations is difficult or impossible.

*Perception.* We perceive our environment with all our senses. In particular, when you are in a process of innovation you need an abundance of different stimuli in order to develop new ideas. These opportunities are ubiquitous in the physical world we live and interact in.

*Volatile.* The paths and steps we follow in the process of ideation and prototyping are hard to capture in the physical world. Each state of differentiation is volatile. Also, undoing decisions and alterations of physical artefacts up to a certain point is usually not possible.

*Simplicity.* A technology that offers such opportunities should be low-threshold and self-explanatory because casual users should be able to use it as well. Executed actions (such as capturing) need to give feedback about the status because users need to know whether the action was successful or not.

*Invite exploration.* People are more likely to try out new things if they know that they can restore prior achievements and have saved their good work results. However, if this requires a lot of effort, people are unlike to take these actions.

*Remote access.* Today's meetings are often held remotely. Only sharing audio and video limits the collaboration.

*Capture.* One need an option to capture the development process without seams between different media to avoid loss of information. Capturing interesting results should happen immediate and not interrupt the flow of works.

## 4.4 Solution

Therefore, provide an instant technology to digitize objects and process results of the real world with one action step. Such a service needs to run continuously or should be triggered with one-click to capture data directly without any delays.

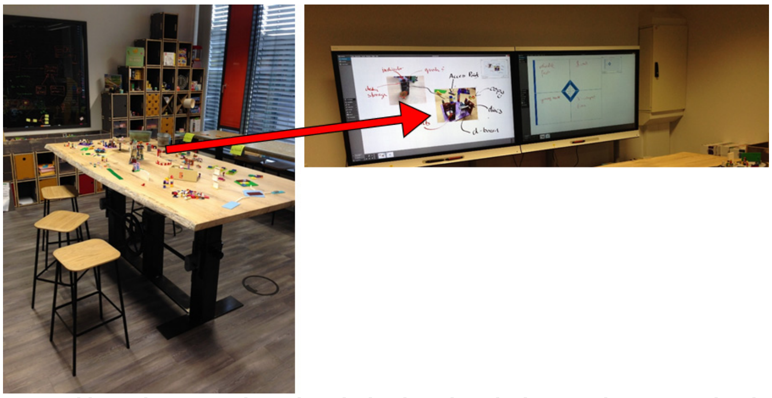

Fig. 3. Work results on a table can be captured to a digital whiteboard. Each photo can be annotated and saved for later use.

Some examples of technology for instant capturing are:

- Smartphones to capture sketches or prototypes
- HP Sprout for 2D and 3D capturing
- Wolf Visualizer
- Digital Camera

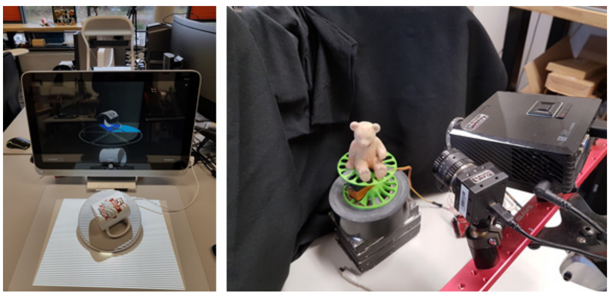

Fig. 4. Automatic 3D scan with HP sprout, and DIY camera setup for 3D scan.

## 4.5 Benefits

*Extended reality.* By representing physical objects in the digital world we will lose their haptic properties. On the other hand we gain new properties that are not given in the physical world.

*Editing options.* Results can be saved and edited independent of time and location. Objects can be duplicated with one click, annotated with additional information, and edited with simple actions.

*Beyond limits.* In the physical world you can do whatever the physical world allows you to do – but not more. The limitations in digital space on the other hand are set by the software environment.

## 4.6 Liabilities

*New limits.* Editing capabilities may exceed the capabilities of the physical world but they are limited by whatever the software offers.

*Interference.* Some people may feel uncomfortable in a space equipped with many cameras (or other capturing devices) because they feel observed or spied on. Hence, they will no longer act freely in the space and this may have negative impact on the creativity.

*Overwhelming.* In general a space with a lot of technology inside might cause irritating feelings when users are overwhelmed or feel threatened by the technology.

# 5. DIGITAL TO REAL

Blending the digital world into the real world

## 5.1 Context

You are designing a prototype or a concept in the digital world. You can work on a single workstation or share a collaborative digital space.

## 5.2 Problem

Digital artefacts are like thought experiments. They are great to explore and tinker with alternatives. But they are not the real thing. They tend to hide limitations, opportunities and side effects of the real world.

## 5.3 Forces

*Rich editing.* Digital tools provide rich options for editing artefacts digitally, such as 3D models, sketches, mind maps, plans or plain texts. Very often setting up or defining properties is a complex task that needs rich editing tools, e.g. modelling 3D objects or program robots or small devices.

*Theory and practice.* Exploring concepts or models that have impact in the real world on a theoretical level only will not show all effects of their practical realization. It's hard to imagine how the objects feel and operate in the real world. Very often there are hidden side effects that can only be seen if the real artefact is tested. At some point you need to test your ideas and concepts.

*Conversation with artefacts.* Design thinking suggests that creators should have a "conversation" with physical prototypes to test their real properties. However, sometimes creating and manipulating objects in the real world is very difficult or expensive. Hence, it is not always possible to work with real materials right away.

*Space.* Objects in the real world consume physical space (which may be limited). Physical objects are often bound to specific locations whereas digital artefacts can be manipulated everywhere. On the other hand, the presence of artefacts makes them more important because putting something into physical space (which is a scarce resources) implies their priority over other things. People put more focus on things that are present permanently.

*Scope of experiences.* So, at the one hand side we want to benefit from all the tools and manipulation features of the digital world. At the other hand we want to explore, test and tinker with objects in the real world.

## 5.4 Solution

Therefore, bring digital artefacts into the world by creating real world versions (e.g. 3D prints, photo prints, regular prints).

Digital tools provide many alternative modes of editing. Different versions of a digital artefact can be saved. Thus, exploring alternatives is encouraged and less risky. In the digital world you have fast access to millions of objects and building parts, using libraries and web resources. Moreover, you can blend different media such as text, images, videos etc. seamlessly.

Thought experiments and manipulations of design should be limitless in digital space, the physical version on the other hand illustrate the limitations of our physical world.

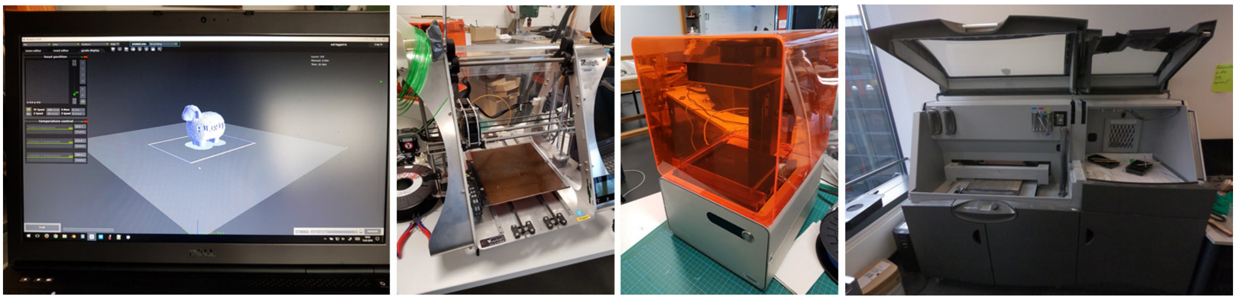

Fig. 5. Digital editing and physical 3D printing.

Examples:

- Put 3D printers into a maker space in order to explore object properties.
- Print out texts to spread them out on the table, mark with a pen or cut out pieces and rearrange them.
- Have a photo printer in a design room.

## 5.5 Benefits

*Haptic experience.* Physical objects can be touched to determine their haptic properties.

*Rich editing.* Physical objects allow fast and natural interaction and exploration, as well as they allow fast and rich manipulations.

*Cost reductions.* Models and prototypes are cheaper than building the real object.

*Exploration.* Many variants of an object can be created quickly to explore alternative properties.

*Optimal use of space.* Paradoxically, very often the work space in the physical world is larger than in the digital world (for example a table top or a wall is larger than a computer screen) but the total available physical space is limited (you can have millions of 3D objects on a hard drive but only a few printouts in the room).

## 5.6 Liabilities

*Device orchestration.* Orchestration between devices from different manufacturers is often a limitation, since interfaces are not disclosed or the devices are not compatible with each other.

*Know-how.* Users need more knowledge of how to connect devices, because they often do not know all the possibilities that arise from the interconnection of them. In particular, the use of production equipment requires additional knowledge from users, especially if the production is expensive, difficult or dangerous (e.g. superglue or epoxy resin for the infiltration of 3D objects).

*Initial investments.* Production devices for high quality results (3D prints, photo prints) are often very expensive and require a high maintenance and consume a lot of resources (e.g. printing materials).

*Cleaning and maintenance.* Creating physical objects often creates a mess and somebody has to take care of the work environment (e.g. a ROOM CONCIERGE).

## 6. HYBRID ANNOTATION

In the design process nothing is final. People discuss and explore different alternatives and provide plenty of comments. There is a frequent need to annotate artefacts with comments, brainstorm ideas or think visually.

### 6.1 Problem

We do not want to spoil the original artefact with our annotations.

### 6.2 Forces

*Comments.* Very often we want to comment on something by writing notes on it. Having notes separated from the artefact is complicated and does not naturally connect to specifics of the artefact. For example, if you want to write down comments for a prototype (e.g. a mock-up or screenshot) it would be great to write directly at the spot you want to comment on.

*Spoiling.* Writing on photos, objects, maps, or any kind of media spoils the artefact. You can do that only once. And some objects have a surface that does not allow any notes on it.

*Natural.* Annotating should be quick, intuitive and natural without a lot of setup steps. Writing down something should be low-threshold. There should be no limitations to the symbols or sketches someone adds.

*Together.* In a group several people, everyone should be able to comment at a product or prototype at the same time and sometimes even from different locations.

*Unbound workspace.* The workspace for large ideas should be unlimited.

*Templates.* Writing into templates (such as business model canvas or SWOT analysis) can support the discussion and trigger thoughts. However, you cannot carry with you all the templates one can think of and drawing a template or matrix ad-hoc takes quite some time. It would be great to have a toolkit of templates, and one could quickly chose the right one when needed.

*Flexibility.* Texts and sketches should sometimes "stick" to certain parts of an artifact, at other times it should be possible to change or erase written texts directly.

### 6.3 Solution

Therefore, enable handwritten notes on digital artefacts. Provide interactive whiteboards or tablets with pens.

Handwriting is the most personal and intuitive way to annotate. Users can quickly encircle areas, use their individual symbol system and sketch dynamically on any digitalized media. They can draw on top of photos, objects captured by a document camera, maps, screenshots, and templates.

Enable users to instantly create digital versions of their physical artifacts (INSTANT CAPTURING), to write on them whenever needed. Provide digital versions of physical work materials as well, such as templates and canvases, sticky notes, screen layouts of smart phone apps.

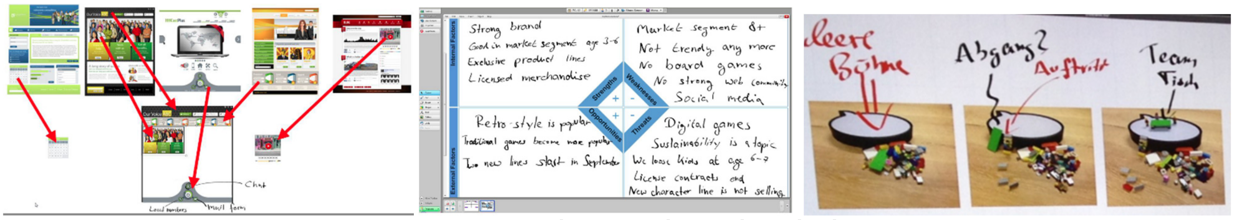


Fig. 6. Writing on websites, templates and Lego bricks.

Examples:

- Take a photo of artefacts, notes, prototypes and write on it
- Open a business model canvas and write on it
- Make a screenshot and write on it
- Use material from the web and write on it

### 6.4 Benefits

*Rich editing.* Digital handwritten notes can be edited (scale, duplicate, move, erase, change color).

*Annotate everything.* Add annotations to any object in the virtual world.

*Share with the world.* Remote editing is possible. Results can be stored, re-stored and shared via communication media (e-mail, blogs, wikis etc.).

### 6.5 Liabilities

*Costs.* Infrastructure of digital whiteboards can be expensive.

*Know how.* Users need to understand the available hardware, software and the appropriate methods.

*Unnatural experience.* Writing experience is not as good or natural as with real pens

## 7. SPEECH CONTROL

Use your own voice to setup the workspace.

### 7.1 Context

Many design processes are supported by specific tools, templates and methods. A blended innovation space can offer both digital and non-digital versions of these. Very often the support tools, templates and methods are stored in different locations and users have to find and organize them accordingly.

### 7.2 Problem

Accessing the appropriate tools, templates or actions for a task at hand in a digital environment can take a lot of steps and is an obstacle in direct interaction.

### 7.3 Forces

*Getting lost.* Very often we know what to do (e.g. fill out a business model canvas) but not where to find it. At other times users of innovation rooms are not aware of the available tools and actions. When they search for specific tools they cannot be sure whether they will find what they are hoping for. Even in a well-organized environment, a user needs to know where to find what. A long search process – successful or failed – interrupts the flow of work.

*Flow interruption.* Tools should be available ad-hoc when needed. Searching for tools can interrupt the flow of work and thought. Sometimes switching between different modes of working can interrupt the flow as well, for example when you are in a heated discussion or you are exploring a vague thought, writing down the ideas can already interfere with your thinking.

*Dependence on location.* Working on an artefact very often takes place at one part of the room, far away from other tools. Moreover, working on an artefact might require you to hold things and use both of your hands.

## 7.4 Solution

Use Speech control to trigger actions, open or create content.

Sending commands can simplify user interaction because a sequence of actions can be expressed as simple terms:

- “Open the business canvas model”
- “Change the light to an inspirational mood”
- “Show me where I can find scissors”
- “Move the robot arm up”
- “Add sticky node ‘global summit’”
- “Add ‘global summit’ to mindmap”

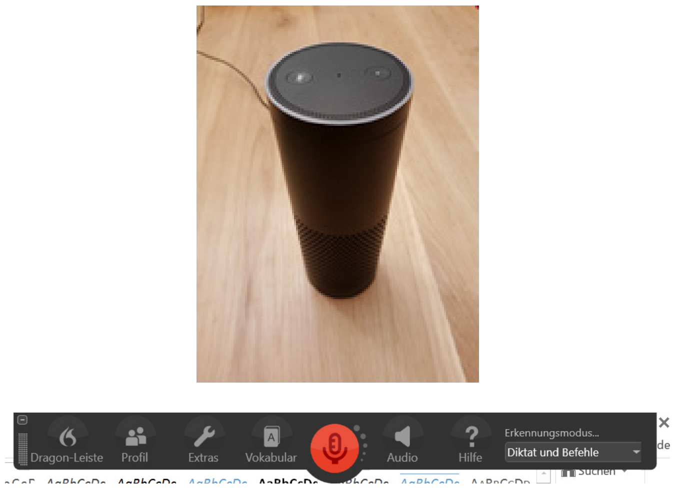

Fig. 7. Amazon’s Alexa (standalone) and Dragon Natural Speaking (on a PC)

Spoken language can be used for many different things. It is universal. Instead of clicking through a lot of sub menus one can access very special operations from a wide range of different options. The meaning of the spoken terms automatically set the context of operation.

While a user still has to learn which terms can trigger action, the access to each action is straight forward.
An (experiment) extension of this pattern would be an automatic analysis of spoken language. For example, if a user says: “Generate mindmap now” or “Generate word cloud now”, the spoken language can be analyzed for key terms that are automatically added to a mindmap or word cloud. Likewise, interesting nouns could trigger automatic loading of Wikipedia pages to provide additional information.

Systems such as Amazon’s Alexa or Dragon Naturally Speaking can learn commands and one can define customized actions for a design environment.

## 7.5 Benefits

*Magic.* Access to information, tools, activities and templates is faster, more natural, flexible and – cool!

*Fast access.* One can find things quickly. Speech is a natural way of interaction.

*Accessibility.* Accessibility is enhanced because actions can be trigged from any place in the room without using hands.

*Uninterrupted flow.* The flow is not interrupted because a simple command can trigger actions that otherwise need a long sequence of clicks, drag and drops or browsing through files.

## 7.6 Liabilities

*Misinterpretation.* If the spoken language is interpreted incorrectly, the correction may take way more time and the flow is interrupted strongly. Spoken accents or mumbling can easily lead to misinterpretations. Misinterpretation that lead to critical actions in the digital or physical world could do harm. Deleting and correcting wrong content or commands is time consuming.

*Noise.* What happens if there are a lot of background noises or many peoples speak at the same time? Which command should take priority?

*Privacy issues.* There is also a privacy issue, especially when the recorded speech is analyzed on external servers. This might even be a legal issue. Being the victim of espionage is a threat that makes users feel uncomfortable. This uncomfortable feeling can be an obstacle to create and discuss innovative ideas openly. Users should have full control to switch speech control on and off – on both software and hardware level.

*Requires learning.* Users need to learn and remember the commands. This could take longer than actually looking up the tools manually.

# 8. CONCLUSION

Most of the identified design patterns have been implemented in the innovation room. They have been a very good planning vehicle. The patterns are based on observation, analysis and experimenting with existing solutions.

As we planned the room, patterns have helped to evaluate existing technologies. We were able to check whether their features match with our requirements. The medium abstraction level of patterns has helped to make specific implementation decisions and to justify them. Both positive and negative impacts of a decision were made transparent. For example some patterns make life easier but are a thread to privacy. Explicitly naming new problems in the consequences, enables us to search for complementary solutions. Sometimes, the patterns have unrevealed technology gaps (e.g. for device orchestration) which need to be filled in the future.

The patterns have helped to communicate the room elements to other stakeholders. The reasoning of patterns helps to justify extraordinary elements in the room (such as Lego, toys, and cards). Moreover, the patterns have helped to divide a complex room composition into manageable parts. Each part can be focused on separately without forgetting its context.

We will continue to describe all of the mined patterns in more detail and elaborate on the known uses and variations. We hope to compile a booklet and a deck of cards that enables other organizations to design their own innovation spaces.

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