Hochschule für Angewandte Wissenschaften Hamburg
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Master Thesis

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Adapting agile methods to support creativity in interdisciplinary projects

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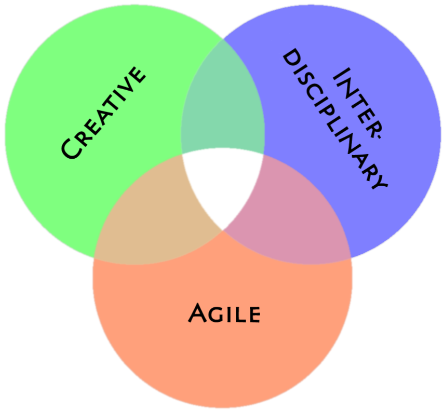

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Abstract
This thesis is about the question whether agile methodologies are suited to support creativity in interdisciplinary projects and what adjustments would be necessary for this purpose. These studies are based on observations made in preliminary studies about interaction design. For this, projects are considered as an integrated system where actors, methods and surrounding conditions interact with each other. With regard to creativity, conclusions are drawn from these interactions in order to find appropriate measures and adaptations.

Thema der Arbeit
Anpassung agiler Methoden zur Förderung von Kreativität in interdisziplinären Projekten

Stichworte
Agile Methodologien, Diversität, Interdependenz, Interaktionsgestaltung, interaktive Kunst, Interdisziplinarität, intrinsische Motivation, Innovation, Kreativität, Kreativitätstechniken, Kontext, Kursdesign, Leitfaden, Methoden, Persönlichkeitsprofile, Projektmanagement, Rahmenbedingungen, Raumgestaltung, Software Engineering, soziale Aspekte, Teambildung, Teamführung, Transdisziplinarität

Kurzzusammenfassung
Diese Arbeit beschäftigt sich mit der Frage, ob agile Methodologien geeignet sind, um Kreativität in interdisziplinären Projekten zu fördern. Weiterhin wird untersucht, welche Anpassungen hierzu notwendig wären. Beobachtungen aus Vorstudien im Bereich "Interaction Design" dienen als Grundlage für diese Untersuchungen. Dabei werden interdisziplinäre Projekte als ganzheitliches System betrachtet, um die Wechselbeziehungen zwischen den jeweiligen Akteuren, Methoden und Rahmenbedingungen in Bezug auf Kreativität nachzuvollziehen und zu berücksichtigen.

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It shan't be forgotten.

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1. Introduction

This thesis is about an adventure that brought together all kinds of people who crossed frontiers out of curiosity and against all odds in order to discover something new and potentially wonderful. The starting point of this adventure has been the question whether or not computer science can enrich the work of various creative people and vice versa. This thesis will demonstrate that such a combination can go well together despite diverse obstacles. These obstacles will be examined in detail in order to develop possible countermeasures. These measures were first based on agile methods, which have their origins in software development; they have then been refined and adapted in such a way that they support creativity even in the most diverse projects. The outcome is a guide that assists people to identify what needs to be done in regard to methods, surrounding conditions, and team composition. By considering a project as a whole, it's assumed that creativity can be created, maintained, and amplified on an ongoing basis.

Florida (2012) predicts the rise of the creative class and its crucial impact on economy and society in the next decades. The outgrowths are already visible today by digital art, digital urban living[1], street festivals[2], flashmobs, augmented reality[3], interaction design[4], or social interactive media[5]. The clash of new technologies and mixed teams is the basis for the upcoming creative and cultural process. This thesis will suggest and examine measures that may push this process even further.

1.1. Related works

This thesis is inspired by the works of Martin (1994); Resnick et al. (2009b); Buechley (2010) who combine learning and intrinsic motivation with computer technologies to foster creativity. Please note that this thesis isn't intended to improve creativity in agile methodologies although most of the following measures could be used for this purpose. Artificial creativity, creative learning, patent rights, or design principles of creativity support systems won't be discussed either. The latter has already been examined by Shneiderman (2007).

[1] Such as http://vimeo.com/26030147 or http://livingplace.informatik.haw-hamburg.de/blog/
[2] Such as http://youtu.be/Ikwhb_GACSA
[3] Such as http://www.ingress.com or http://youtu.be/9c6W4CCU9M4
[4] Such as http://youtu.be/LNC5_17H-1A or http://www.andrejeworutzki.de/interactive/
[5] Such as http://www.snibbeinteractive.com

1.2. Outline

This thesis is primarily based on observations collected in preliminary studies which are described in the following chapter 2. The subsequent chapter 3 defines the three concepts that represent the essential parts of this thesis: agile methodology, creativity, and interdisciplinarity. This chapter also introduces the context wheel and emphasizes the importance of interdependence. This interdependence is examined within the next three chapters 4, 5, and 6 in detail whereupon each chapter examines all three concepts from a special point of view. Chapter 4 is about personal aspects including traits, leadership, and team composition. Chapter 5 is about social, conditional, and environmental aspects. It introduces aspect pairs that affect creativity either in one way or another. These aspect pairs are used for the design, analysis, and comparison of courses and projects. Chapter 6 suggests methods which are based on agile methodologies. They have been adapted and extended in order to support creativity in interdisciplinary projects. The following chapter 7 summarizes the adaptations that have been made to agile methods. It also includes the intention behind each adaptation. Findings from this thesis are presented at the end of this chapter. The final chapter 8 looks back on the central points of this thesis. Further topics, that would go beyond the scope of this thesis, are outlined including future prospects. Finally, this chapter takes the meta-level of the three mentioned concepts into account and gives some thoughts to their meaning in general.

2. Preliminary studies

Ambient Awareness[1] was the first course across multiple departments and disciplines at the HAW Hamburg in 2008. Within the next years, and with an acquired research funding of 50.000,- Euro, further *interdisciplinary* courses followed. These courses varied considerably and covered the exchange of ideas between students from different disciplines, experiments with new materials for human-machine-interaction, education of pupils and design students into embedded computing, and research of interaction design and wearable computing. Due to the success of these studies, further interdisciplinary courses still follow. Some of them focus on specific topics like affective computing[2] or camera-based interaction[3]. Moreover, an open workspace, also called FabLab, has been established at the HAW Hamburg since 2011 where students from all departments are able to work together, help each other, and share their ideas.

This thesis is primarily based on observations made in these studies. Nonetheless, statistical investigations from external sources and literature are additionally taken into account. But first of all, this chapter will be about the observations made in the preliminary studies including key elements, design of exercises, room setup, process, and lessons learned.

[1] See `http://ambientawareness.org` and Gregor (2009)
[2] See `http://interactivedesignlab.de`
[3] See `http://computationalspaces.org`

The following table 2.1 lists all the past courses that are part of the preliminary studies. It contains the type of each course, the duration, and details about the participants. More detailed information can be found in Jeworutzki (2009, 2010); Müller (2010). Some visual impressions can be received from figure 2.1 on the next page.

Course	Type	Duration	Participants	Age	Disciplines
Sonia (internship)	class	3 weeks	1	15	pupil
Margaretha-Rothe I	class	1 semester	10	12-13	pupils
Margaretha-Rothe II	class	1 semester	12	17-18	pupils
Smart Objects	class	1 semester	8	>18	CS, D, ME
Toaster Edwin[4]	workshop	2 weeks	15	>18	CS, D, EE, MD
Faszination Games I+II	workshop	1 day	10 + 9	8-12	kids
Herbsthochschule I+II	workshop	2 days	12 + 14	8-14	kids
Smart Textiles	project	1 semester	4	>18	CS, D, FD, MD
Bachelor Thesis (Keune, 2010)[5]	project	1 semester	3	>18	CS, D, ME
Diploma Thesis (Helene All, 2011)	project	1 semester	6	>18	CS, D, FD, FE
FabLab / Emotion Lab	project	continuous	varying	>18	any students

Table 2.1.: Overview of the preliminary studies

Legend: CS (computer science), D (design), FD (fashion design), FE (fluid engineering), EE (electronic engineering), MD (media design), ME (mechanical engineering)

Although all courses have teamwork and interaction design (working with microcontrollers) in common, the focus may differ depending on the particular type:

- class: focus on instruction and teaching
- project: focus on self-organized teamwork
- workshop: a combination of class and project

This thesis is mainly about projects and workshops, however, classes and teaching will be addressed at some points too. Further information on designing creative learning environments can be found in Resnick et al. (2009b); Mähl et al. (2010); Roque (2012).

[4] See http://toasteredwin.de
[5] See http://svenja-keune.de

Figure 2.1.: Some impressions of the preliminary studies

2.1. Key elements

The common subject of all courses is interaction design: course participants work on installations or mobile objects that are able to sense humans, or even their behavior, and react to them accordingly. The goal is to augment and deepen the experience between human and machine. Such interactive objects are equipped with one or more microcontrollers, small computers that are in this case based on Arduino and LilyPad[6]. The kind of interactivity depends on the programming of the microcontroller as well as the attached actuators and sensors which can cover a wide range of elements, for example, audio, gestures, light, projection, motion, touch, or video[7]. Participants are usually provided with a class-room-kit that contains all necessary components for first experiments. Additionally, a large variety of tools and materials is provided in order to support all kinds of ideas. Appendix A contains a more detailed list of possible components, materials, and tools. Experimental components are also offered for further research. However, it often takes much more time to obtain suitable results which is the reason why experimental components are of limited use for quick prototyping. The results, created in each course, are always published either by an exhibition or a final presentation.

The course participants range from kids and students to teachers and professors who may all come from different disciplines and professions. The course participants work in randomly mixed teams, from now on referred to as *interdisciplinary teams*. Each interdisciplinary team is self-organized and works on self-defined ideas. The general emphasis of each course is rather on practical work than on lectures. That's why exercises, prototyping, and self-organized teamwork are primarily promoted in all courses. If necessary, coaches support or train the teams. Coaches play a passive role, they only step in if a team becomes too ambitious and may lose control in terms of feasibility. Moreover, coaches ensure that all teams frequently exchange their ideas and experience with each other by setting up meetings and presentations. Coaches also ensure that all teams document their experience and reflect on their work regularly.

Apart from that, all teams are given as little constraints as needed in order to provide as much opportunities as possible and to respect the different interests and backgrounds of each participant and team. The constraints are always adapted to the given circumstances, they depend highly on the intention of a course (e.g., collaboration, experiments, learning) and on the particular participants (e.g., age, divergence, skills). The following section goes deeper into the design of exercises which are characterized by a minimum of constraints in order to get all participants involved as quickly as possible.

[6] See http://www.arduino.cc

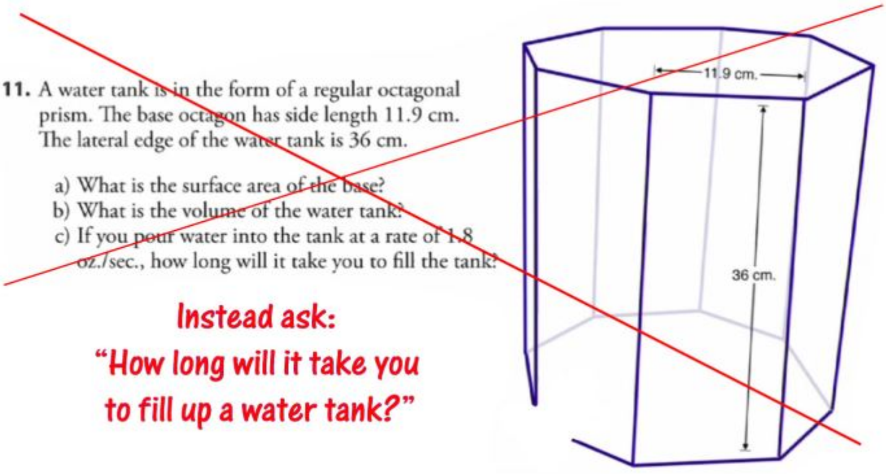
[7] See some examples on http://vimeo.com/18970588 or http://youtu.be/aMNKcdUGQmw

2.2. Open problem statements

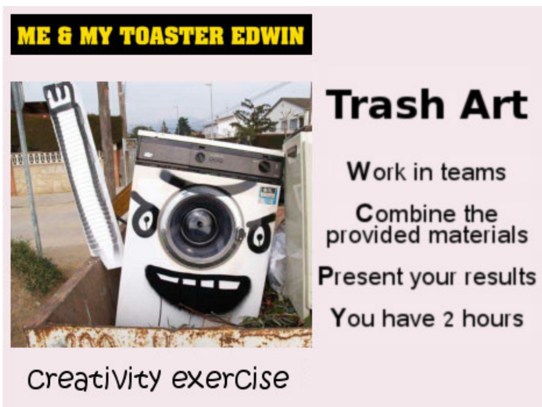
Open problem statements are exercises or tasks that facilitate creativity. This is achieved by asking unspecified questions that offer many paths and many answers but no single answer.

> *Convergent thinking involves aiming for a single, correct solution, whereas divergent thinking involves creative generation of multiple answers to a problem. (Guilford, 1967)*

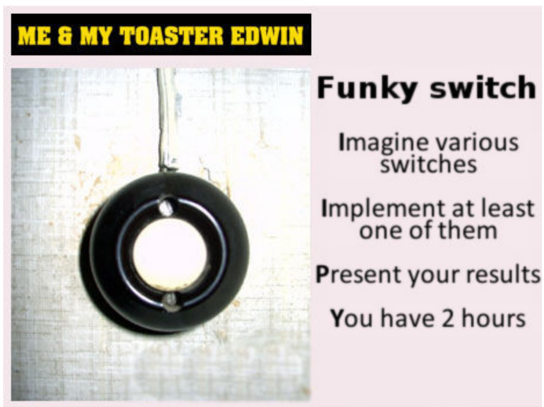
Only a vague outline of a problem is given. Participants have to figure out how to solve them. This leads almost always to different solution strategies. Open problem statements enable everyone to join in the conversation because the mere use of well-known strategies and formulas won't work. If accompanied by experiments, they enrich discussions even more and give a deeper understanding of how to approach problems in the real world. However, open problem statements usually cost more time and may end in unpredictable solutions. And they must be adapted carefully to the particular participants in order to avoid excessive demands.



(a) Water tank exercise based on Dan Meyer: http://blog.mrmeyer.com



(b) Trash art circuits



(c) Funky switch

Figure 2.2.: Examples of creativity exercises in compliance with open problem statements

2.3. Room setup

Besides exercises and materials, the room setup affects creativity and group work as well. The following suggestions have been refined over time. Further arrangements should depend on the particular location. Additional rooms should be made available nearby if one room doesn't provide enough space. Similar setups are discussed in Rosseburg (2007); Resnick et al. (2009b); Mähl et al. (2010).

A team workplace is called *island* and consists of a free-standing table and chairs around it. This layout particularly supports face-to-face communication. The table size decides how many team members are able to work on a specific island. It should support at least two members but not more than eight. All islands are distributed in the room but still within reach of each other so that all teams are able to swap ideas and to help each other. However, there should be enough room left between the islands so that each one remains easily accessible and supports bystanders who want to have a quick look or provide assistance. All chairs should be able to roll and rotate which makes rearrangements more comfortable, especially in case of frontal presentations and talks. Islands aren't bound to a team, each island can be occupied by any team at any time.

The walls are decorated with bulletin boards, posters, or displays that show blueprints, tips, news, and inspirational (past) works. Large whiteboards enable all teams to do quick drawings in collaboration. Lockable cabinets should be located on the side. They store shared materials

(a) Islands and presentation area

(b) Whiteboard

Figure 2.3.: Room setup for creative work

and tools but also separate materials of each team. The cabinets should provide enough room to comfortably store test rigs without taking them apart each time. Keys are handed over to the teams, combined with free access to the room. This allows all teams to work on their project at any time.

The room itself should be public and open to visitors. It's either located centrally to boost visits or remotely to ensure an undisturbed working environment. If possible, creative people from different disciplines are in the sphere of influence (Florida, 2012; Obermeyer, 2010). The room should be as large as possible so that teams have enough space for visitors, test rigs, and meetings. Windows should provide plenty of light, however, for tests or projections, it should be possible to darken the room. Plants, decorations, and music provide a pleasant working atmosphere. It's also a good idea to divide the room(s) into areas that fulfill different purposes:

- Free space for test rigs, meetings, or visitors
- Individual retreat areas for rest or undisturbed work
- Lounge with, e.g., coffee maker, comfy chairs, fridge, microwave, music, snackbox
- Presentation area for lectures and talks including projector and screen
- Showroom that exhibits prior works
- Storage room to store large or past works
- Workshop area for shared materials, tools, and workbenches (see also appendix A)

In case of multiple rooms, it's important that they are located within reach of each other to avoid long walking distances. The following floor plan in figure 2.4 gives an example of how a room might be divided into different purposes. It's based on the FabLab at the HAW Hamburg.

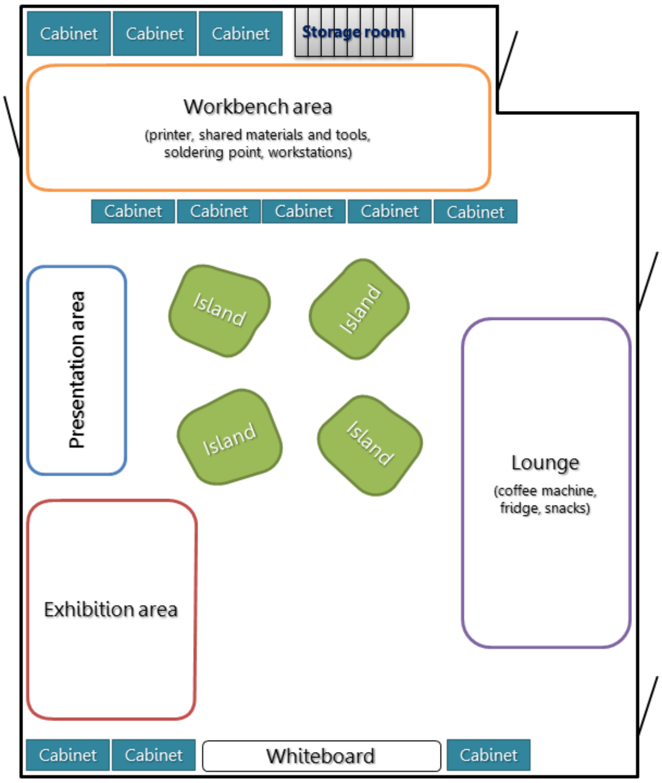


Figure 2.4.: Floor plan of the FabLab at the HAW Hamburg

2.4. Process

Figure 2.5 outlines the general process used in all courses. It consists of four phases: preparations, introduction, basic lectures / processing, and final. Each phase contains several modules which run either in parallel or take turns. Especially the modules in the longest, third phase

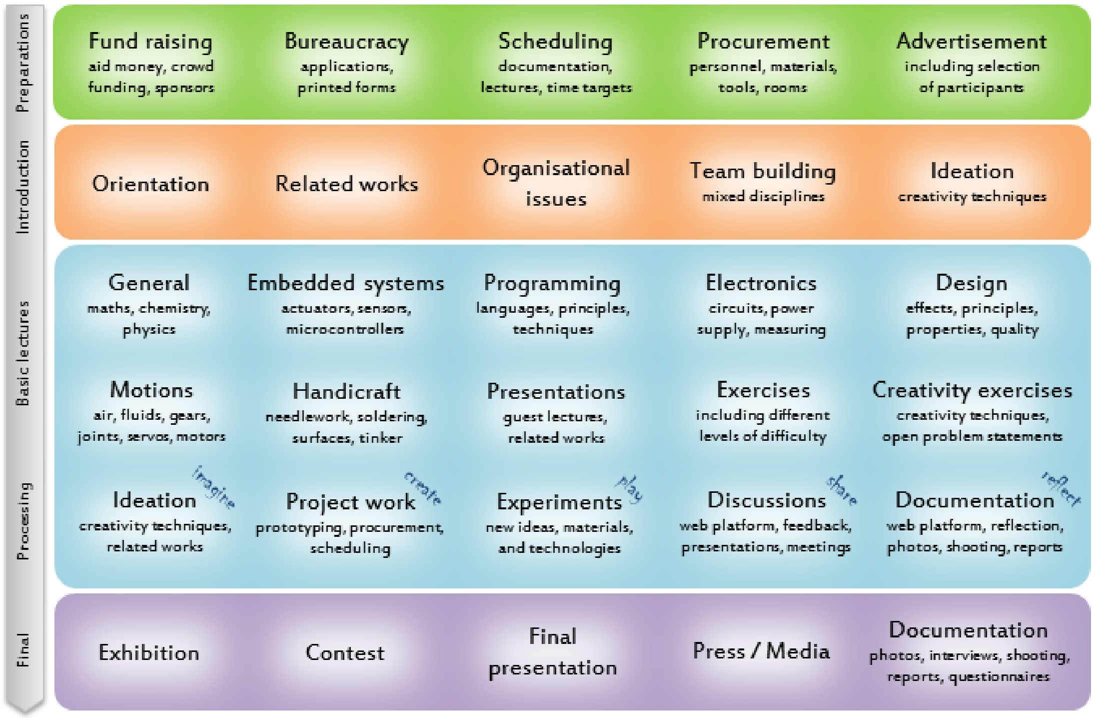


Figure 2.5.: The general process used in the preliminary studies

take turns constantly. Modules located in basic lectures are more likely at the beginning whereupon modules located in processing will gradually replace them over time.

All modules, except for the ones in processing, are optional. The optional modules depend on the specific requirements of a course such as time limits, course objectives, and knowledge and skills of the given participants. The basic lectures can also be extended with further specialized modules according to the particular requirements of a course.

The described process is based on the more abstract Creative-Thinking-Spiral, shown in figure 2.6, and demonstrates how it might be realized in practice.

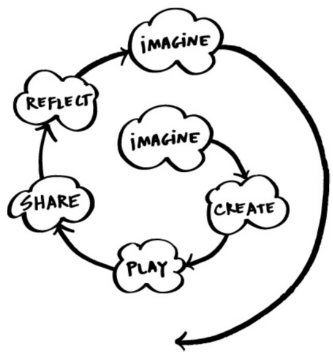


Figure 2.6.: Creative-Thinking-Spiral by Resnick (2007)

From the point of view of a course designer, this process ensures the following objectives:

- mixed teams and self-organized project work right from the start
- early ideation ensures that the interests of each team are considered properly
- early practical work by creativity exercises and open problem statements
- there are only as much lectures as needed - teams become quickly independent
- independent project work invites teams to experiment and test new ideas
- all teams are frequently inspired by presentations and related works
- exchange of experience and feedback is fostered by regular discussions
- regular documentation ensures that all teams reflect on their work

2.5. Lessons learned

This section is about the problems that commonly occurred during the past courses. It explains how these problems have been handled and how they might be handled best.

Documenting the course

Proper documentation of a course is very important but also time-consuming. Especially photography and video shooting require additional preparations, personnel, and effort during the course. Writing reports takes time too. The crucial point is that missed documentation cannot be made up in good quality afterwards. But good quality is essential for both references and preparations of future courses.

Using open problem statements

The less guidance and constraints are given, the less predictable are the results. Especially free (creative) work, as described in section 2.2, is very difficult to predict. Course instructors need then many skills and a wide range of special knowledge in order to assist participants properly. The trick here is to move from the traditional approach, in which instructors know all the answers, to a cooperative approach, in which instructors aid participants in finding a proper solution. Course instructors should still look out for too ambitious ideas and set up constraints to prevent participants from overstretching their capabilities and resources.

Preparing interdisciplinary courses

Interdisciplinary teams have widespread needs and interests. Taking them into account is a complex matter - especially in advance. This includes, for example, adapted promotion for each separate discipline, proper anticipation of necessary materials and tools, or finding a common topic in which each discipline is interested in.

Preparing interdisciplinary lectures

It makes preparation of lectures very challenging if participants have a different knowledge base. Especially if there is only little information about the participants available. This can be approached by preparing multiple exercises that cover different levels of difficulty for each discipline. This is very extensive and still requires prediction. Having basic lectures is another approach that brings all participants on a similar level and additionally provides a basis for a common language. The problem of basic lectures is that they may be very boring for participants (experts) of the respective discipline. Letting participants teach each other is a further approach which ensures that everyone is engaged, however, not all participants are good teachers. Individualized lectures, adapted to the interests of each participant or team, can be a viable approach, but they demand a substantial number of instructors. Open problem statements and creativity exercises, as described in section 2.2, are well suited for interdisciplinary teams because they don't require participants to be on a same level of knowledge. However, creativity exercises tend to be more time-consuming than traditional lectures because they lack of constraints and uniform solutions.

A further problem is the balance between theoretical and practical course units. Practical exercises are sometimes impossible without specific knowledge. Short lectures, that are less than 30 minutes, followed by exercises of different levels of difficulty give participants the chance to work out the theoretical matter on their own. This requires careful design of the exercises though. Open problem statements and creativity exercises can be very useful in this regard.

Another important point is coherent scheduling. If a lecture takes place for two hours a week, only little progress is possible. Time for assembling and disassembling has to be considered as well.

Preparing courses and lectures for kids

First, age and maturity need to be considered. Some kids need more instructions than others, an adequate number of instructors may be required. These instructors should be able to work with kids in partnership in order to foster independent work on individual ideas. Second, a topic is needed that is challenging but not too difficult - most "cool" topics require a lot of knowledge and skills. A viable approach might be to pick just any topic and let the kids make it become cool. Another, but risky, approach is to give kids the impression that the given topic is cool. Finally, each lecture should end with a successful experience, even if the results don't work as desired. Kids sense it if instructors pay too much attention to the results. Attention should be given to the kids instead. A lecture for kids should primarily result in a remarkable experience including activities that are fun and worth remembering.

Interdisciplinary teamwork

Since special languages and expressions aren't understood by other disciplines, interdisciplinary teams need to develop their own common language. The more disciplines are involved, the more diverse the languages but also the way of thinking. Different language and thinking are the main reasons for misunderstandings - especially at the beginning. Depending on the number of disciplines, it usually takes several months until a team develops its own common language and becomes fluent. Close collaboration and frequent meetings across the disciplines accelerate this process. Non-formal sketches are very useful in this regard because they can illustrate a complex matter without the need of a special language[8].

A further challenge are responsibilities that blur over time. As long as each discipline works on its own, responsibilities are clearly distributed. However, this separation is usually not possible in interdisciplinary teams. Ambiguous and unbalanced responsibilities may be the greatest challenge to overcome in interdisciplinary teamwork. A separation like "designers provide the ideas and engineers implement them" doesn't work out in most instances because it's prone to unbalanced separation. The symptoms often appear with considerable delay: demotivated team members whose interests aren't properly taken into account due to the lack of participation or responsibility. It seems to be more sustainable to build teams rather by common interests than by chance as it was done in the preliminary studies. However, teams with real common goals are hard to find because team members tend to believe that their goals are shared with all other members even if this isn't the case. That's why regular consulting and meetings are vital activities for interdisciplinary teamwork.

Instead of having interdisciplinary teams, another approach is to train universal team members. For example, teaching designers to be engineers. Designers can indeed learn how to program and how to plug circuits but hardly any of them become independent from engineers in order to implement own prototypes that go beyond simple sense-then-act-interactions. Nonetheless, such trained designers are often far better in understanding engineers and working with them.

Creative work on interactive objects

First of all, creative work tends to be messy and requires a rule for cleaning up: "Leave the lab cleaner than you found it". Besides that, lack of time is almost always the main limitation of creative work. It takes time to develop *the* idea. This process requires rather a proof-of-concept than assumptions and planning. Assumptions usually don't turn out as desired and plans

[8] "Point it" is a similar concept: `http://www.graf-editions.de/en/pointit/`

become quickly obsolete in a creative process. An idea seems to evolve faster when a team actually starts working on it. Maintaining the momentum is very important in this connection, especially in terms of motivation: teams that remain on a conceptual level are prone to change their ideas excessively at frequent intervals. If such a situation persists for a certain period, often less than a couple of weeks, confusion and loss of motivation are very likely.

Prototyping helps teams to shape their ideas over time in order to find a trade-off between technical constraints and desired design. An idea may be excellent on the paper but once it has to be implemented, it may quickly turn out unworkable or unaesthetic due to unforeseen implications. Beyond that, prototyping fulfills the following functions:

- feasibility is checked
- progress becomes visible
- aesthetics can be evaluated
- next targets are easier identified
- possible problems are discovered early
- ideas become more vivid and comprehensible

As discussed next, prototyping isn't a silver bullet. It implies rules that are sometimes in conflict with flexibility and freedom - both often needed in creative work.

Prototyping interactive objects

Prototypes have to be developed in small steps, otherwise teams tend to overextend themselves and start to reach for too ambitious goals. In accordance with the principle *divide et impera*, small steps make it easier to test new features since prototypes remain less complex and error-prone. As illustrated in figure 2.7, damageable and error-prone prototypes are a big issue because they are difficult to handle and beyond that of no use for exhibitions. Such prototypes are good for quick feasibility studies that won't be used any further. But if a prototype acts as a platform for further experiments, robustness pays off in the long term. For example, the design and production of printed circuit boards (PCBs) cost extra time but may improve robustness and reusability. Nevertheless, a prototype shouldn't be considered as a reliable product; such quality requires a considerable amount of money and

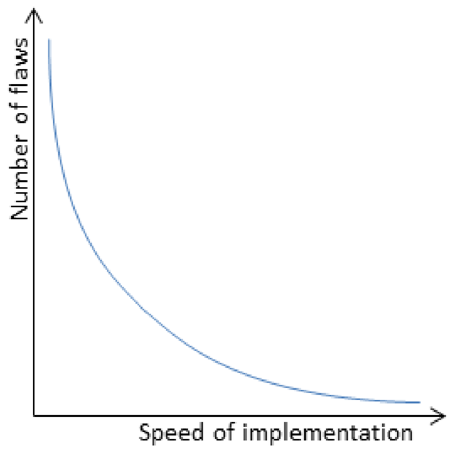


Figure 2.7.: Working on error-prone prototypes is more time-consuming

resources plus thorough elaboration in advance. All in all, it's important to keep prototypes separated by their purpose:

- Throwaway prototypes for proof-of-concepts, design and feasibility studies
- Evolutionary prototypes for further experiments, refinements, and maybe exhibitions

Whatever type is used, it's essential to implement prototypes stepwise. Interaction design is a difficult affair because complex topics (design, hardware, and software) are combined. Small steps prevent tedious error diagnostics right from the start. For example, attaching just one servo might work well, a second servo may already lead to several, even random errors that are hard to trace, but at least it's known that the second servo is the cause in some way. The commonly used all-in approach, in which all components are assembled right from the start, makes error diagnostics nearly impossible - sticking to the example this would mean to start with ten servos plus further components. The best approach in such a case is to test each component in isolation first and then combine them gradually. Trial and error is only recommendable for rapid throwaway prototypes. Prototypes that cover many aspects should be separated into multiple smaller prototypes first, before they are combined stepwise.

Maintaining interactive prototypes

The more complex a prototype, the more maintenance is required. This results in the need of long-term availability of the responsible team. Such availability is especially vital if teams don't document their work properly - documentation is rarely done on a voluntary basis because new tasks permanently emerge and postpone documentation further. Little documentation may imply less reflection. But reflection is essential for learning from made mistakes. Separation of documentation is a further problem which often occurs in interdisciplinary teams: documentation is kept separated by each discipline due to distinct documentation styles. Course instructors can improve this situation by frequently prompting team members to document their work, reflect on it, and share it among each other.

Transportation of interactive prototypes

Prototypes are often transported, either to exhibit them or to continue work somewhere else. Assembling, disassembling, robustness, and compactness are important factors in this regard. Additional time and potential defects have to be considered for assembling, disassembling, and transportation. Heavy, large-scale prototypes aren't suitable for transportation and they often tend to violate the *keep it simple* principle. Moreover, disassembling isn't always possible due to conglutination, soldering, or welding. Costs may also increase if materials aren't reusable. The following questions should be addressed on time:

- How long is a prototype needed?
- Are the used materials needed anywhere else?
- Who will dismantle the materials afterwards?

Another issue is that irrevocably disassembling may reduce the motivation of participants. Certificates, records, and pictures alleviate this effect somewhat. Offering participants to buy a prototype may be a viable option too.

Considerations concerning production of interactive prototypes

The following table 2.2 lists considerations concerning production of interactive prototypes. They're based on Sukale (2008) and have been refined and extended[9]. Please note that most of them are mutually exclusive and require a trade-off, e.g., seamless versus maintainable. More sophisticated features, in terms of interaction, will be discussed in section 6.4 (think different).

Consideration	Explanation
Economic	low priced materials, quickly and easily procurable
Flexible	free of design constraints and technical constraints
Intuitive	no manual is needed even if the function isn't obvious
Maintainable	colored and labeled materials, no cable spaghetti, no sealed black box
Parametrical	non-programmers are able to add and test new behavior in real-time
Proof-of-concept	iterative prototyping, small steps, quick feasibility checks
Reliable	steady cables, robust against contact, tested assembly
Responsive	comprehensible or instant feedback, smooth and organic transitions
Reusable	easy assembling and disassembling, plug&play
Scalable	easy to extend by a modular design, plug&play
Seamless	technology disappears into the design and vice versa
Simple	focus on the core idea, not overloaded with features
Stand-alone	easy activation/recharge, runs without attendance/special knowledge
Transportable	compact, pluggable, not bulky, not heavy, robust

Table 2.2.: Considerations concerning production of interactive objects

[9] Original: autonomy, flexibility, integration, low-cost, reliability, reusability, scalability, and usability.

Ideas and results in regard to interactive prototypes

The results are usually very original, but with regard to interactivity, they often lack in complexity and diversification. In most instances, the interactive prototype just waits for a certain event and then reacts to it. Once it has finished, it starts waiting for the next event again. Interactivity should include surprising, unexpected, or unusual elements otherwise it becomes quickly uninteresting. Dynamic, smooth interaction is also welcome but much more difficult to implement, especially for beginners and non-programmers. The lack of skills often hampers ideation and implementation. Ambitious goals increase the problem even further, for example, if a team tries to implement physical motion without having at least one expert in kinetics at hand. Sophisticated interaction design requires experts who are able to implement it in time as well as tools that support artists, designers, and non-programmers properly.

Exhibiting interactive prototypes

It's a great motivator for teams if their results are exhibited. Moreover, exhibitions give them the opportunity to socialize and get inspired by other works. But exhibitions make also new demands on the prototypes: transportation, reliability, and maintenance become important requirements which stand in contrast to experimental prototypes. It's important to schedule extra time so that the prototypes can be prepared and hardened for an exhibition. Furthermore, prototypes have to be easily accessible in case of malfunctions or empty batteries. This implies that someone is continuously around and watches over them. A "watchdog" may also be necessary to secure the exhibits and tools against destruction and theft.

A further issue are artistic, non-functional prototypes that are less intuitive and hard to present. It may be bad design if exhibits need plenty of instructions or even an instructor, however, some people may argue that playful exploration is a vital part of the design. Anyway, the right attention and communication is necessary so that interactive elements aren't missed by the visitors, especially if they don't expect interactivity or if they are afraid of breaking the exhibit.

2.6. Conclusion

All courses within the preliminary studies cover a wide range of topics such as hardware, software, and design issues but also location, prototype quality, and organizational issues. Interaction design is a key aspect of the preliminary studies which demands iterative prototyping in order to cope with frequent change of creative work. Many considerations in terms of design and implementation are needed for the development of interactive prototypes.

Proper preparation is needed to adapt a course to the given participants. This includes the design of open problem statements in such a way that exercises provide room to be creative. The room setup and room layout affect creative teamwork as well; there should be enough space, tools, and materials available for various experiments. A process based on the principle "imagine, create, play, share, reflect" further supports creative work. Maintaining the momentum is crucial in this connection; course instructors should prompt teams to come to an agreement in time. Passive course instructors ensure that participants can work out their ideas autonomously. The participants are divided into teams that mix different disciplines. Such interdisciplinary teams are likely to come up with a wider range of ideas. But they have to find a common language and common interests first. Finding a common language and understanding takes time and requires much collaboration until the extra effort pays off and the team can benefit from synergy effects.

This thesis will discuss creative work in interdisciplinary teams from the perspective of a computer scientist and course designer. Although education and interaction design are part of the preliminary studies, they won't be discussed in detail. The upcoming chapter 3 will introduce the essential concepts used in this thesis.

3. Concepts

After presenting the results of the preliminary studies in the previous chapter 2, this chapter discusses the terminology used in this thesis including agile methodology, creativity, and interdisciplinarity. The contextual interdependence of these concepts will be addressed at the end of this chapter.

3.1. Creativity

Among many other definitions, the following is used for creativity in this thesis:

> *Creativity is defined as the interaction among personal, process, social, and environmental factors by which an individual or group produces an idea or product that is judged to be novel or has value either to oneself or to others. (based on Lassig (2009))*

What is considered to be creative depends on the point of view and may also be a matter of opinion. In general, three stages of creativity are distinguished (Gardner and Simon, 1999):

1. Trivial: adapting something existing, e.g., a recipe (learning level)
2. Personal: creating something novel to oneself (learning level)
3. Historic: creating something novel to others (society level)

Whereupon historic often requires expert knowledge and years of intensive work in one area.

Invention is 1% of inspiration and 99% of transpiration. (Thomas A. Edison)

One of the earliest models of creative processes is attributed to Wallas (1926) who proposed four phases: preparation, incubation, illumination, and verification. In contrast to non-creative processes, incubation and illumination are important components here. They implicate the need of extra time in which no visible progress is made. In this regard it's interesting that people seek creativity although it seems to be less economic. The answer is probably innovation, a term commonly understood as the result of creativity, however, studies are inconclusive in this regard. Nonetheless, innovation seems to be the main reason why creativity is proposed and desired in education and economy these days. Please note that innovation is in some ways a part of this thesis, but it won't be defined or discussed in detail.

Intelligence is another term that is frequently used in connection with creativity but various studies come to different results and have found no clear correlation so far (Neubauer and

Stern, 2007). What is known is that creativity is no innate ability and can be learned and trained (Cropley, 1991). According to Robinson (2001) and Resnick (2009), people seem to lose their creativity the more they grow up. Education is considered as reason for this phenomenon which can be particularly observed in schools where children are taught to memorize and reproduce instead of finding solutions on their own (Guilford, 1967; Schaub and Zenke, 2008; OECD, 2010).

> *I don't believe that we don't grow into creativity, we grow out of it. Or rather, we get educated out of it. (Robinson, 2006)*

Many organizations have recognized that memorized knowledge cannot solve problems. New technologies, like the internet and smartphones, make memorized knowledge even less important. The ability of finding creative solutions becomes more and more relevant. However, the way creativity is valued remains conflicting: on the one hand, academia and industry point out how important creativity is, on the other hand, creativity is barely supported by the given structures and processes. There is no place for individual needs and incubation time in an efficient organization, creativity is rather subordinated to standardization, tight schedules, and verification in order to optimize time, risks, and costs. Creativity is messy and requires additional efforts, more efforts than "just being creative". Being creative means to cope with the unpredictable including failures and setbacks but also comebacks. Economic organizations spend more attention to domain-relevant skills than to creativity-relevant skills. That's maybe the reason why creativity is rarely mentioned in present curricula or job descriptions in Germany (Beck, 2007; Gesellschaft für Informatik, 2008; Behörde für Schule und Berufsbildung, 2010; Pfisterer et al., 2011) - the most requested skills and traits are based on collaboration, engineering, and science. Schools consequently comply with the requested requirements of the industry. This results in a selective, "fast food" education embodied by MINT (2012) and the bachelor's degree as part of the Bologna Process (Scholz, 2006; Holland-Letz, 2008; Dörre and Neis, 2010).

> *Every education system on earth has the same hierarchy of subjects. [...] At the top are mathematics and languages, the humanities, and the bottom are the arts. Everywhere on Earth. [...] that the most useful subjects for work are at the top. [...] And the consequence is that many highly talented, brilliant, creative people think they are not because the thing they were good at school wasn't valued, or was actually stigmatized. (Robinson, 2010)*

New technologies have become a catalyst for creativity today. Instead of just consuming the radio and television programs, everyone is now able to create and share creative work around the world. Various tools are available to be creative but proper training isn't. Many people are creative in an autodidactic way because they're supported by creative common licenses, free distribution and funding channels, plugin and modding-kits, and open hardware as well as open software (Mota, 2011). These are all examples for creativity on a voluntary basis - in the end, it shouldn't be forgotten that being creative is also fun including self-motivation and enjoyment of life.

> *I meet all kinds of people who don't enjoy what they do. They get no great pleasure from what they do. They endure it rather than enjoy it and wait for the weekend. (Robinson, 2010)*

All in all, creativity is a controversial matter because it's hard to quantify. This thesis acts on the assumption that any measure can be used to achieve creativity as long as it is in accordance with the particular situation. So, one and the same measure can either increase or decrease creativity depending on the particular context. This assumption implies that creativity should be inspected on a regular basis. This inspection should cover the following topics:

- How does the organization and its people understand creativity?
- How to establish a common understanding on creativity?
- What is the value of creativity? Why is it pursued?
- How is creativity recognized and valued?
- What needs to be done to foster creativity in the particular context?

This thesis will suggest many measures to improve creativity, measures that coexist among many others, the crucial point here is that any measure needs to be considered as contextual.

3.2. Interdisciplinarity

In this thesis, interdisciplinarity is understood as the collaboration of people across age, culture, discipline, gender, language, profession, religion, and social status. This definition covers a wider range than traditional ones which refer only to different academic disciplines; it's also strongly related to transdisciplinarity (Nicolescu, 2002). Interdisciplinary teamwork is all about combining ideas, practices, and methods of multiple sources in order to increase diversity, divergent thinking, and eventually creativity. A multiplicity of examples for interdisciplinary work can be found in Frodeman et al. (2010) which range from business and industry to education and science. Please note that all courses in the preliminary studies, as described in chapter 2, are based on interdisciplinary teamwork whereupon computer science is primarily mingled with other disciplines.

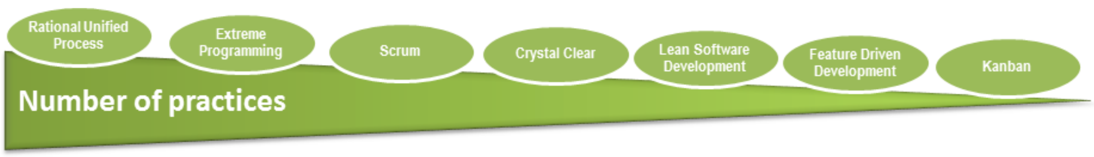
3.3. Agile methodologies

Agile methodologies were developed in the 1990s as a reaction to the bureaucratic software engineering methodologies such as the V-model, waterfall model (Winston, 1970), or spiral model (Boehm, 1986). Fowler (2005) highlights two distinctive features of agile methodologies:

1. They are rather adaptive than predictive
2. They are rather people-oriented than process-oriented

Agile methodologies are based on short iterations in which work is scheduled on recent feedback of the customer. That's why agile methodologies are able to adapt quickly to changes, emerging requirements, and misconceptions. This fact makes them promising candidates for creative work.

About a dozen agile methodologies exist up to now. Among the most well-known are Crystal Clear (Cockburn, 2004), Extreme Programming (Beck and Andres, 2004), Feature Driven Development (Luca, 2001), Kanban (Anderson and Reinertsen, 2010), Lean Software Development (Poppendieck and Poppendieck, 2003, 2007), Rational Unified Process (Kruchten, 2003), and Scrum (Schwaber, 2004). Some of them define only processes whereas others define also specific engineering practices. The Rational Unified Process, e.g., is more similar to a construction kit because it offers a very large collection of practices and processes to choose from. Extreme Programming, on the other hand, lists very precisely which practices have to be used. Despite all these differences, the Agile Manifesto (Beck et al., 2001) covers the general



(a) Each methodology offers a different amount of rules and practices

(b) Each methodology offers a different amount of optional rules and practices

Figure 3.1.: Agile methodologies roughly compared

principles being shared by all agile methodologies for the most part. The Agile Manifesto itself is more a guiding principle than an implementable methodology.

Please note that agile methodologies are mostly multidisciplinary, not interdisciplinary. Indeed, Extreme Programming defines on-site customers as practice (Farell et al., 2002; Koskela and Abrahamsson, 2004) but it isn't widespread among agile methodologies (Ambysoft, 2009; VersionOne, 2013). Disciplines remain usually separated by domain (developers and customers). So, each domain retains its autonomy and original identity. The existing structure of knowledge isn't questioned.

3.4. Contextual interdependence

As indicated in figure 3.2, all three presented concepts overlap to some degree. The question is how well do these three terms fit together and on what terms? This will be answered in the course of this thesis.

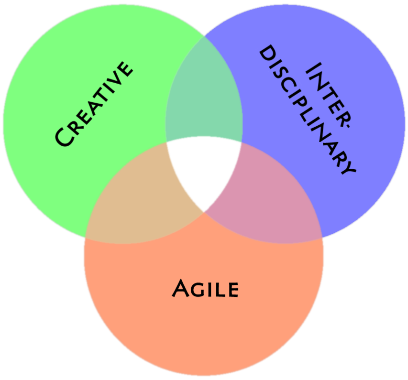


Figure 3.2.: The CIA circle

Moreover, it isn't sufficient to consider each concept in isolation. This is often done in popular literature about creativity in which one or more aspects are picked and disproportionately accentuated. Systems thinking is needed instead: the process of understanding how things influence each other (Meadows, 2008). Creativity depends on the particular context, or in other words: the context affects creativity and has to be considered as a whole. Amabile (1996b) specifies seven major levels at which creativity forces operate: sufficient time for producing novel work in the domain, people with necessary expertise, funds allocated to the work domain, material resources, systems and processes for work in the domain, relevant information, and the availability of training. The following figure 3.3 summarizes these major levels[1]:

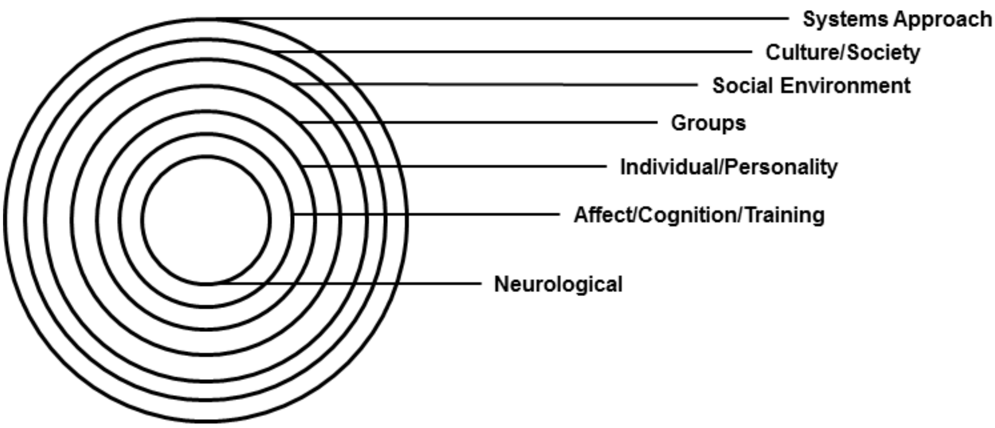


Figure 3.3.: The major levels at which creativity forces operate. Source: Amabile (1996b)

[1] Please note that neurological aspects won't be addressed in this thesis.

The context wheel, shown in the following figure 3.4, illustrates the same statement in another perspective. It consists of the same seven major levels which surround and influence project work. It will be shown in the course of this thesis that these levels also influence each other. In order to improve creativity, all levels (hereinafter called aspects) have to be considered in a particular context before appropriate measures can be taken. This also includes a general debate on how creativity is understood and valued in that context.

Figure 3.4.: The context wheel illustrates how project - or rather creative - work is shaped

3.5. Conclusion

The three terms creativity, interdisciplinarity, and agile methodology have been discussed in this chapter. Creativity is the most controversial term since no standard definition and metrics exist. Interdisciplinarity is about teams that are characterized by a diverse mix of people. Agile methodologies are more adaptive and people-oriented than prior software engineering methodologies. Although different agile methodologies exist, they still share the same principles constituted in the Agile Manifesto.

This thesis will examine these three terms and there points of intersection. Seven major levels (aspects) of creativity are used for this analysis. It will be shown that all terms and aspects depend on the particular context and influence each other; the following three chapters will examine all aspects in connection with agile methodologies, creativity, and interdisciplinarity.

4. Personal aspects

This chapter investigates personal aspects which include the demands on individuals, groups, and skills. For this, the following three groups are distinguished and examined:

1. Creative individuals
2. Agile software developers
3. Interdisciplinary team members

First of all, this chapter highlights the personality traits of each particular group. The three groups are then compared against each other including their distinctive features. Each group is further separated into team members (e.g., participants, students, or employees) and team managers (e.g., coaches, leaders, or instructors). Other groups are indeed relevant to creativity but not part of this study (e.g., customers, directors, or sponsors). A further part of this chapter covers different team roles and the question how a creative team composition is achieved. Possible selection processes, like aptitude tests, are discussed at the end of this chapter.

4.1. Personality traits

A great deal of traits are supposed to have a positive impact on creativity. The following figure 4.1 visualizes the most common creativity traits in literature. A detailed list, including the respective sources, is located in table B.1 on page 116.

Figure 4.1.: Creativity traits

Please note that each list of traits tends to be incomplete and should be treated with caution.

> *Case studies [...] revealed just how difficult the attempt to identify individual difference variables essential for creativity has proven to be.* (Amabile and Hennesse, 2010)

The next figure 4.2 illustrates the skills and traits that are characteristic of agile software developers, the detailed list is located at table B.2 on page 117.

Figure 4.2.: Agile traits

Agile methodologies are accounted for small, self-organized teams that collaborate with their customers. The requested traits reflect this circumstance consequently. All in all, many agile traits (B.2) comply with creativity traits (B.1) as shown in the condensed table 4.1:

Kind of compliance	Traits
Direct compliance	focused, humble, independent, knowledge, motivated/passionate, relaxed, responsible/elaborative, skilled
Similar compliance	brave/courageous, certain/confident, change/playful, equal/tolerant/respectful
No compliance (agile traits)	collaborative, communicative, cooperative, customer-oriented, feedback, team-oriented, trustworthy
No compliance (creativity traits)	comprehensive, curious, empathic, extraverted, feeling, humorous, imaginative, introverted, joyful, naive, objective, stormy, versatile

Table 4.1.: Agile traits compared to creativity traits

Traits with direct compliance are primarily knowledge-based and needed for work. Traits with similar compliance are based on openness and flexibility. Agile traits that don't comply are mainly needed for collaboration and teamwork whereas creativity traits that don't comply are about the individual being including emotions and mind. For example, the agile trait "customer-oriented" stands in contrast to the creativity trait "intrinsic". The reason for this distinction lies in the different motivation: agile developers are supposed to service their customers whereas creative people strive for their own ideas and self-realization.

> *For me, one of the most important traits in a [agile] programmer, or indeed in a development team, is something that I'll call Customer Affinity. (Fowler, 2012b)*

Agile methodologies rely on cross-functional teams composed of interchangeable programmers. Although business people or customers are involved, they are commonly not an inherent part of agile teams (on-site customer) as indicated in Ambysoft (2009) and VersionOne (2013). Interdisciplinary teams, in contrast, are composed of engineers and non-engineers. Each interdisciplinary team member shares different expertise which is why they are usually not interchangeable. In order to benefit from synergy effects, interdisciplinary teams have to find a common language and consolidate their different working styles. Their traits reflect this circumstance as visualized in figure 4.3 (see also table B.3 on page 118 for more details):

Figure 4.3.: Interdisciplinary traits

Interdisciplinary traits focus on teamwork and social competence including collaboration, communication, and trust. These traits comply in large part with agile traits as shown in the following table 4.2. Curiosity and openness are interdisciplinary traits that comply with creativity traits, both traits reflect probably the reason why interdisciplinary people work with other disciplines in the first place.

Kind of compliance	Traits
Compliance with agile traits	communicative, expertise, humble, passionate, reliable, self-dependent/self-organized, trust, tolerant
Compliance with creativity traits	curious, diverse, empathic, expertise, humble, humorous, imaginative, open, passionate, playful, tolerant

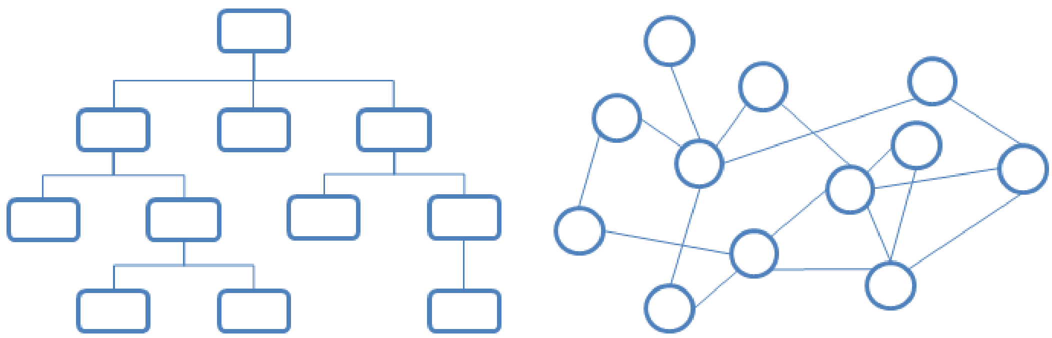
Table 4.2.: Interdisciplinary traits compared to agile and creativity traits

Conclusion

The personality traits that comply in all three groups can be summarized as expertise, humble, and tolerant. Expertise to service other people, to reach own goals, or to augment a team. Humble to know one's own strengths without forcing them on others. Tolerant to be open for change, different views, and new ideas. All in all, the three groups have more in common than they differ. However, individualism, equality, and customer-orientation can be possible points of conflict. An interesting question in this regard, but beyond the scope of this thesis, is if missing traits can be trained afterwards (at the expense of authenticity) or if they have to be trained early on by education. In the latter case, creativity traits should be more valued in education.

4.2. Team managers

Team managers (e.g., coaches, leaders, or instructors) play a crucial role in terms of creativity because they can observe a process as a whole and conduct the necessary adjustments (Urban, 2004). Depending on the activity, team managers usually fulfill many roles at once[1]. Each team manager should focus on two general tasks in order to foster creativity: remove possible impediments and appreciate creative work adequately. The latter differs greatly from the attitude of traditional team managers and demands drastic adaptation from them in regard to authority and autonomy. Being a creative team manager is rather about creating links between independent people than giving instructions as illustrated in figure 4.4:



(a) Traditional, hierarchical leadership (b) Connecting people as modern leadership

Figure 4.4.: Leadership: traditional and creative

[1] The Team Management Wheel, e.g., specifies eight manager roles: explorer/promoter, assessor/developer, thruster/organizer, concluder/producer, controller/inspector, upholder/maintainer, reporter/advisor, and creator/innovator (Margerison, 2002)

The following figure 4.5 illustrates the continuum of leadership behavior by Tannenbaum and Schmidt (1958). It classifies seven leadership styles from boss-centered to subordinate-centered.

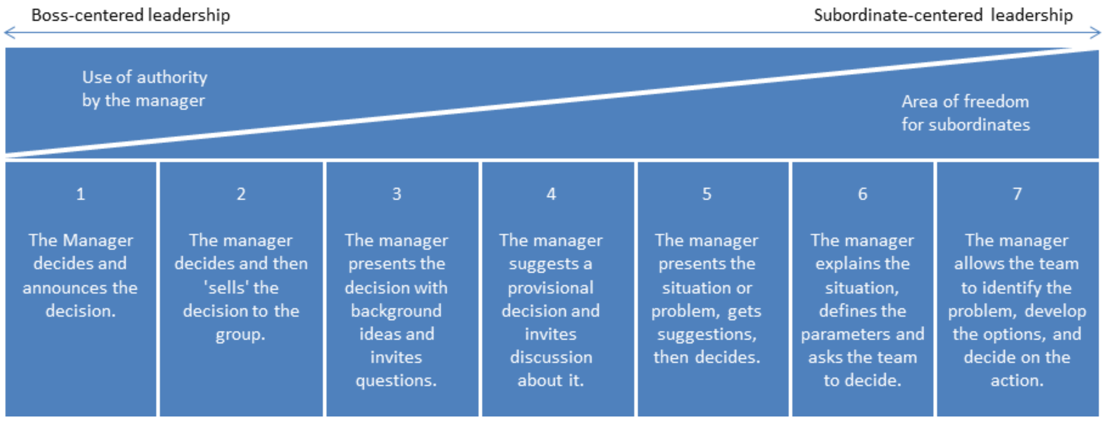


Figure 4.5.: The continuum of leadership behavior by Tannenbaum and Schmidt (1958)

Hersey et al. (2012) argues that the leadership style is situational: It depends on the general conditions and on the level of maturity of the employees. Rahn (2010) suggests group-oriented leadership in which the leadership style is determined by the individual group members or by the nature of the whole group. The transformational leadership model describes the influence of managers on subordinates by providing identity, stimulation, and motivation (Bass and Avolio, 1993). However, there is no explicit model of leadership for creativity and interdisciplinarity. In order to support creativity and intrinsic motivation, a subordinate-centered leadership style seems to be more suitable in which team members have a certain amount of freedom for experiments and own ideas. Most agile methodologies define a strong subordinate-centered leadership in which agile team managers act as passive supporters. Agile teams coordinate, decide, and prioritize their tasks in collaboration with their customers. It's usually up to the individual agile team member then how to implement the set tasks. However, agile team members still consult each other in regular meetings before they get started.

All in all, no common leadership style exists. Subordinate-centered leadership seems suitable for creative and interdisciplinary work but there is no evidence for this assumption. The leadership style should be chosen on the basis of the given surrounding conditions (e.g., organization type, responsibility allocation, risk management, tasks, time limits) and individuals (e.g., engagement, experience, skills, traits, trust).

The following table 4.3 lists a variety of potential "creativity killers" being commonly made by team managers (and to some extent by team members as well). Each of these actions can indeed hamper creativity, especially if excessively and unilaterally applied. However, some actions may even improve creativity if they fit into the particular situation. The next chapter 5 will go deeper into the matter of opposing aspects, for the time being, such lists should be treated with caution.

Action / Behavior	Examples
Authoritarian	Directives and instructions only, responsibility isn't shared
Competition	Win-lose situations are frequently caused within a team
Conformity	Peer pressure, obsession with single right answers and ideologies
Conservative	Clinging to past success, change and risks are avoided
Control	No autonomy, no delegation, no self-employment
Devil's advocate	Every proposal is neglected, pessimistic criticism
Disrespect	Discrimination, distrust, frequent skepticism
Evaluation	Creativity has little value, behavior is driven by ratings
Impatience	Multiple attempts and mistakes aren't allowed
Indecisive	Goals are frequently changed or not clearly defined
Information hiding	Needed information isn't delivered or shared
Judgmental	Good and bad classification, prejudgment
Overload	Imbalance between workload and working time
Pressure	Grandiose expectations, relentless deadlines
Restrictive	Limited choice, protocol accordance, insistence on details
Rewards	Excessive use of prizes, no attention to intrinsic motivation
Severe	Fear is spread, play and work are strictly separated
Surveillance	Assigned work is frequently checked

Table 4.3.: Actions and behaviors of team managers that tend to hamper creativity[2]

[2] The list has been assembled and condensed on the basis of various sources: Amabile (1998); Csíkszentmihályi (1997); Ekvall et al. (1999); Kurtzberg (2005); Resnick et al. (2009b); Sternberg (1999); Urban (2004).

Agile methodologies don't necessarily specify a team manager. This is due to the fact that equal teams without hierarchy are favored. However, team managers aren't explicitly forbidden. Scrum, for example, defines the so-called Scrum Master who has little authority and makes sure that organizational impediments are eliminated. A similar role exists in Extreme Programming too, called coach, who additionally helps the team to keep a smooth process by making sure that rules are observed and practices remain "extreme" such as pair-programming, test-first, or user stories.

Team manager	Traits
Agile manager	associated, aware, equal, mediator, reserved, respectful, responsible, result-oriented, supervising, supportive
Creative manager	adaptable, associated, aware, balanced, brave, calm, curious, empathic, encouraging, equal, future-oriented, individual-oriented, reserved, respectful, sociable, spontaneous, tolerant

Table 4.4.: Traits expected of agile and creative team managers

Table 4.4 lists the traits requested of agile and creative team managers. It reveals some direct compliance between them: associated, aware, equal, and reserved. If the description of each trait is closely examined (see also table B.4 and B.5), it turns out that agile and creative managers have much in common since both fulfill a passive, supportive role that stands in stark contrast to the role of traditional team managers who primarily lead and give directives. Creative managers tend to appreciate autonomy and individual interests instead as shown in the following table 4.5 on the next page.

Conclusion

Agile and creative team managers have much in common. Both nearly share the same traits and act in a passive, supportive manner. They eliminate distractions and appreciate individual autonomy. This subordinate-centered style greatly differs from traditional ones. Nonetheless, any manager action can influence creativity either in a negative or positive way. For example, some teams need more leadership than others - leading isn't bad per se in regard to creativity. Especially excessive, one-sided actions tend to hamper creativity though. Instead of sticking to a single dogma, each action should be adapted to the particular team and project. This rule of thumb should also apply to interdisciplinary team managers who primarily act as mediator between the disciplines. In principle, agile, creative, and interdisciplinary team managers complement one another without major contradictions.

Category	Manager's actions that possibly foster creativity
Challenge	Asks the right questions (instead of giving answers). Helps to deal with frustrations and setbacks. Holds balance between ambition and capability. Makes people sensitive to the environment (think outside the box). Provides honest and constructive feedback. Stimulates, inspires, or provokes (e.g., by related works).
Encouragement	Appreciates unique talents, unusual thoughts, ideas, or products. Cares about each individual and his work. Ensures fair trade-off between intrinsic and extrinsic rewards . Makes diverse and stimulating materials available. Nurtures self-efficacy (Bandura, 1997). Provides sufficient recognition and rewards for creativity.
Freedom	Assumes everyone is doing his best unless proven otherwise. Cultivates self-employment and free choice of solution patterns. Supports experiments (even if failed) and free play. Supports self-initiated questions and learning. Supports team actions or team decisions.
Organization	Discovers problems and initiates measures to overcome them. Discusses milestones and watches over the progress. Eliminates distractions so that political problems don't fester. Eliminates restrictions: administration, protocols, and standards. Ensures the right balance between people, resources, and workload. Provides necessary resources: time, money, and space. Provides the opportunity to learn and grow.
Team support	Avoids hierarchy and treats everyone equal. Creates mutually complementary teams. Checks that everyone is involved and motivated. Helps out weak team members. Is sensitive to moods and emotions. Mandates information sharing and collaboration. Matches people with the right assignment. Removes destructive people if necessary.

Table 4.5.: Preferred actions of team managers who support creativity[3]

[3] Collected from various sources: Amabile (1996b); Amabile and Kurtzberg (2001); Edmondson and Nembhard (2006); Ekvall et al. (1999); Payne (1990); Pundt and Schyns (2005); Resnick et al. (2009b); Sternberg (1999).

4.3. Team roles and balance

The observations in the preliminary studies have shown that extraordinary creative teams tend to consist of the following three roles[4]:

1. the spirit who shapes the vision
2. the tinker who loves to experiment and test new stuff
3. the worker who supports the process in every respect

The spirit is very elusive and hard to describe. First of all, the spirit may be the lateral thinker who comes up with the unusual ideas but not necessarily. The spirit is rather the one who enriches ideas with additional meaning, context, and intention. It's about shaping an idea into a coherent composition. The spirit predicts and imagines the essence of an idea and how it'll take effect on the environment. By doing so, the spirit helps to shape the vision, improves the team spirit, and eventually force target-oriented advancement. This might also be achieved in a passive manner based on the spirit's influence on other people, for example, by providing inspiration, motivation, or stimulation.

The tinker is very competent in a particular domain and thus able to create mock-ups quickly. Once something catches the tinker's attention, he or she cannot let go and doesn't stop "tinkering" until a satisfying solution is found. That's maybe why tinkers come up more often with unusual ideas. However, the tinker may be easily distracted by details that are less important for the project.

The worker is often large in number and necessary to accomplish large-scale projects in time. Workers may close the gap of missing skills and knowledge but they usually have limited influence on the design process. Their support ensures feasibility and a smooth workflow.

Both spirit and tinker are essential but rare. Most interdisciplinary teams seem to consist of workers only. Such teams are able to come up with extraordinary creativity too, but it's more unlikely because they often lack excellence, motivation, or team spirit. Additionally, common goals and interests seem to be important requirements for successful interdisciplinary teams (besides to get on well together). As soon as some team members pursue a different agenda or don't enjoy the assigned work, the team is very likely to end up in randomness or patched up results. Even the best balanced team consisting of spirit, tinker, and worker won't change that. This observation should also apply to agile, creative, and interdisciplinary teams.

Opposite team roles that hamper creativity exist as well. Charlatans who pretend to be experts - it's tedious and hard to expose them, especially for team members from other disciplines. Illusionists who believe that all ideas are easily implementable, in particular if

[4] Gardner and Simon (1999), e.g., distinguish four personalities: influencer, innovator, master, and self-observer.

the complexity of other disciplines is unknown or ignored by them. The misunderstoods who cannot articulate their goals and ideas. Divas who believe that only their own ideas are excellent and worth considering. Querulous persons who delay the progress by questioning everything. These are only a few examples, much more exist. Such roles cannot be avoided but handled - preferably as soon as possible in order to keep the negative impact on creativity and teamwork to a minimum. For this purpose, some team members may act as mediator who resolve conflicts. However, mediation implies diplomatic skills and patience without any guarantee of success. Interpersonal and social skills, such as communication and negotiation, are usually assumed but not necessarily present among all team members. This calls for training and should be considered right from the start. Training isn't the ultimate answer, there is always potential for conflict, but training can help to solve them more quickly. All in all, a team that works well together shouldn't be taken for granted. Additional time and effort for conflict resolution and familiarization is almost always inevitable, especially in fresh teams.

Different team roles have been discussed so far, but it's still unknown what roles are crucial for a creative team. The reason for this is that crucial roles vary from team to team and even from situation to situation. As illustrated in the following figure 4.6, creative teams are composed of various roles, but it remains hidden how these roles have to be mixed up.

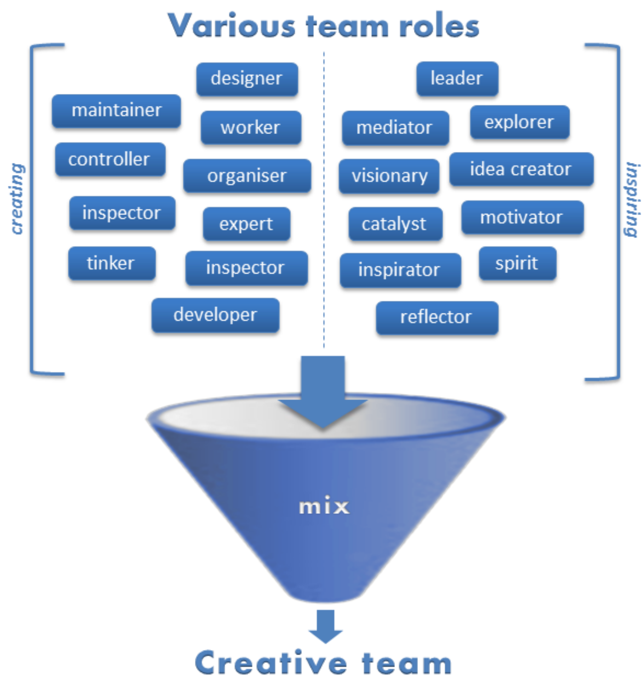


Figure 4.6.: Creative teams are composed of various roles[5]

[5] This figure represents only an exemplary collection of possible team roles.

For example, some creative teams can only work if there is a leader who is taking care of task assignments. Other teams may work better without a leader, especially if all team members are proactive. Other teams may just need someone who provides the unusual ideas. All this leads to the assumption that various roles are needed, not only to get ideas implemented, but also to create a creative spirit within the team. So, a general approach might be to assemble creative teams in such a way that their roles are as different as possible[6]. This diversity may increase the chances of having at least one on the team who is the crucial factor for the creative spirit. However, this approach entirely ignores personality traits and individual personality - not everyone is qualified for a certain role which makes team composition even more complex. Moreover, the right working conditions are needed too (which will be described in the next chapter 5). In summary, the roles within a creative team should be diverse and should depend on the particular conditions, interests, and personalities.

Conclusion

An universal role for creative teams doesn't exist. A well-balanced mix of roles appears to be more suitable instead. The benefit of having diverse teams is that they complement each other and thus have more opportunities at their disposal to be creative. Interdisciplinary teams are naturally more diverse. However, such diversity bears the risk of conflict of interest. Conflict management and training is needed and should be applied early. It's sometimes even necessary to split teams up if they spend most of the time on conflict solving than on creative work. Agile teams, on the other hand, are less diverse because they consist only of equal, interchangeable programmers who already share the common goal of satisfying the customer. Having equal roles and a clear separation of responsibility (programmers implement, customers specify) seems to be less susceptible to internal conflicts. This raises the question whether uniform teams are better than diverse teams? The answer depends on the particular intention: Why has the team been created in the first place? The ideal team composition should reflect the team's purpose. All in all, there is no silver bullet that guarantees a conflict-free creative team. Some fortune and multiple attempts are necessary plus the right conditions, interests, and personalities.

[6] The Belbin Team Inventory, e.g., distinguishes nine team roles: plant, monitor evaluator, coordinator, resource investigator, implementer, completer finisher, teamworker, shaper, and specialist (Belbin, 2010).

4.4. Selection process

Besides traits and roles, other personal factors need to be considered in order to find the right members for a creative team:

- Physical: age, gender, handicaps, and social origin
- Cognitive: capabilities, experience, expertise, language, intelligence, skills and talents
- Preference: cultural, expectations, interests, and style

Individual weaknesses can be compensated if different abilities are distributed among all team members. In general, it's easier to adjust a course or project to the needs of a team than the other way around (Amabile, 1996b). The reason for this is that adequate team members aren't easily found. Defining a target group is a good starting point in this regard. Aptitude tests may be of help here such as the Torrance Tests of Creative Thinking which can be used to test creativity of individuals (Torrance, 1972; Kim, 2006). Certainly, such tests provide only general results and shouldn't be overestimated. An aptitude test should rather be adapted so that it reflects the particular needs of the course or team. Simple questions about personal preferences may already be sufficient for this purpose.

Excursus: Torrance Tests of Creative Thinking

The Torrance Tests of Creative Thinking is a creativity test and commonly used in the USA. It provides exercises that give opportunities to ask questions, to improve products, and to "just suppose". The exercises assess different mental characteristics, e.g., abstractness, closure, elaboration, fluency, originality, or resistance to premature. The "Manual for Scoring and Interpreting Results" is needed to score the results.

Figural

What might this be?

Possible responses:

- a smooshed spider
- a star
- a set of mini blinds caught in a tornado

Verbal

Name all the uses for a brick!
Possible response: a paperweight, a doorstop, breaking (martial arts), to conserve water in a toilet, a mock coffin at a Barbie funeral

More information can be found on http://www.coe.uga.edu/torrance/creativity-resources/

All in all, aptitude tests are a good tool for choosing and filtering potential team members. Moreover, they can help potential team members to estimate if they might fit in. Designing aptitude tests is a complex affair though. A free-for-all approach may be a more economic alternative: let everyone join and find out if he or she fits in. This approach is based on experimental luck indeed. The preliminary studies indicate that random selection works as long as the individual interests don't significantly diverge among all team members. Building teams by common interests and by careful selection should be preferred to random selection because it increases the chances of adequate teams.

Finally, it should be noted that not everyone wants to be creative. Florida (2012) states that everyone is creative and everyone is important for creativity. However, some people don't want to be creative, either because they lack creativity training or they just want to play a supportive role. There's a great temptation to force creativity on people and projects, maybe because creativity has an excellent reputation and is often copied without further ado from successful people and projects.

4.5. Conclusion

This chapter has shown that agile personalities are well suited for creative and interdisciplinary teamwork. Especially agile and creative team managers complement each other: both play a passive, supportive role and take care of smooth working conditions. The traits requested of agile team managers and members correspond largely to creativity and interdisciplinary traits. There are only marginal contradictions. Affective and intrinsic traits are missing due to the customer-oriented nature of agile projects. Empathy and tolerance are especially needed within interdisciplinary teams in order to improve collaboration among the different disciplines. In contrast to uniform agile teams, interdisciplinary teams rely on diversity which promise more opportunities and higher chances of varied results - a team that consists only of multiple Mr. Spocks[7] is most likely to end up with logical results only. But diverse teams tend to be prone to conflict of interest which requires more mediation. Common goals and interests are needed to ensure that all team members are equally involved and motivated. Agile teams already have a common goal which is meeting the customer's needs. Regardless of agile, creative, or interdisciplinary teams, adapted aptitude tests are helpful to find adequate team members for a particular course or project. However, such tests cannot guarantee successful teams. Fortune, purpose, and multiple attempts should be taken into account as well. Fortune involves luck and unpredictable events in economy, nature, politics, or society that are beyond one's ability to plan and control.

[7] A taciturn character from the TV show Star Trek who favors logic over emotion.

As summarized in figure 4.7, team creativity depends on multiple personal aspects: traits, roles, physical, cognitive, and preferences. The ideal team composition should reflect the team's purpose. There are no right traits in terms of creativity and there is no silver bullet that guarantees a creative team - even perfectly balanced teams won't work properly if the given conditions don't let them. As highlighted in the previous chapter 3, personal aspects are only a part of creative work. The upcoming chapter 5 will examine what conditions have to be considered and how interdisciplinary and creative teams are influenced by them.

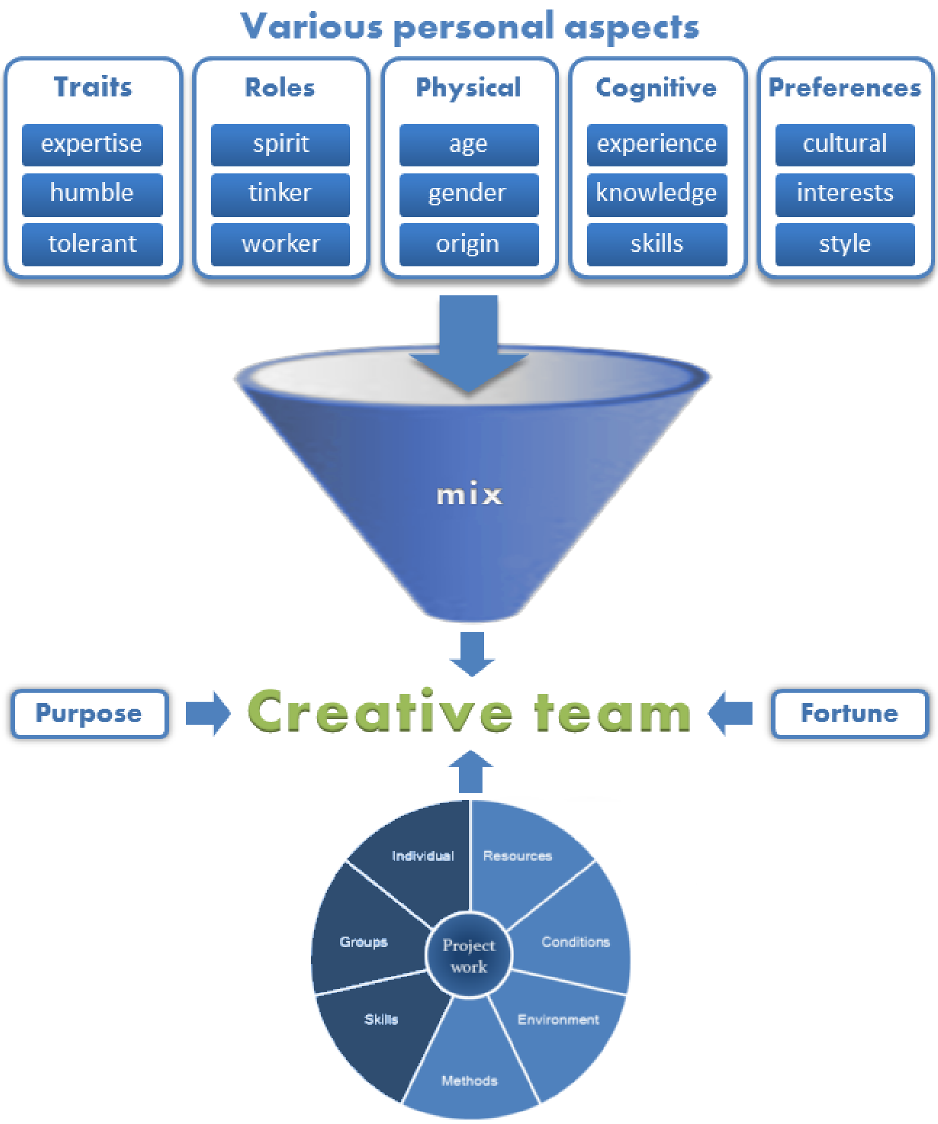


Figure 4.7.: Creative teams depend on various personal and further aspects

5. Social, environmental, and conditional aspects

After investigating the personal aspects in chapter 4, this chapter is about social, environmental, and conditional aspects with regard to creativity in agile and interdisciplinary teams. These aspects are based on the preliminary studies described in chapter 2. The following 19 opposing aspect pairs are assumed to have both positive and negative effects on creativity similar to the ones in Sternberg and Lubart (1995)[1]. Each particular aspect in this chapter have been chosen because it points out important factors and issues of creative work in interdisciplinary teams. They are briefly described and examined in regard to their relationship to agile methodologies and interdisciplinary teamwork.

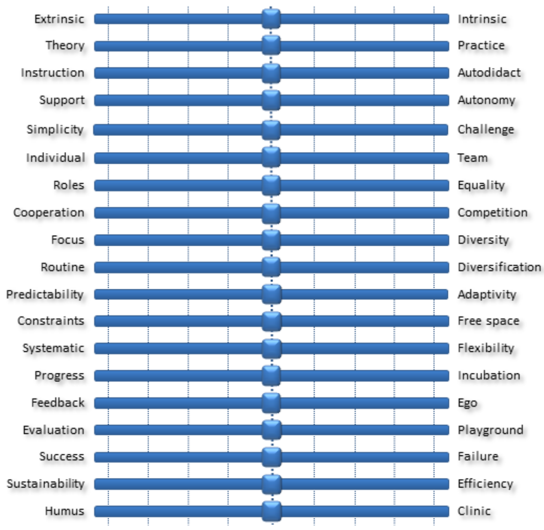


Figure 5.1.: Opposing aspect pairs

Figure 5.1 illustrates all 19 aspects pairs as adjustable parameters. It can be used as a tool to analyze, compare, or plan courses and projects. For example, as soon as one aspect pair tends towards one extreme, it's an indicator that creativity is enhanced but also restricted

[1] Sternberg and Lubart (1995) define the following opposing creativity variables: competition, cooperation, evaluation, general environmental climate, role models, and tasks constraints.

in some way which might be intentional (or not) to suit a particular situation (see also the following figure 5.2). The opposing character of these aspect pairs implies that there cannot be only one true approach to creativity. Each aspect is part of a complex system. Understanding their interrelations allows one to manage creativity in a certain direction in order to achieve a desired result or quality. For example, the call for high predictability often implicates many constraints and systematic methods. Some courses of the preliminary studies will be analyzed and compared in this manner at the end of this chapter. Moreover, preferred conditions will be suggested that appear to be best suited for creative work in interdisciplinary teams.

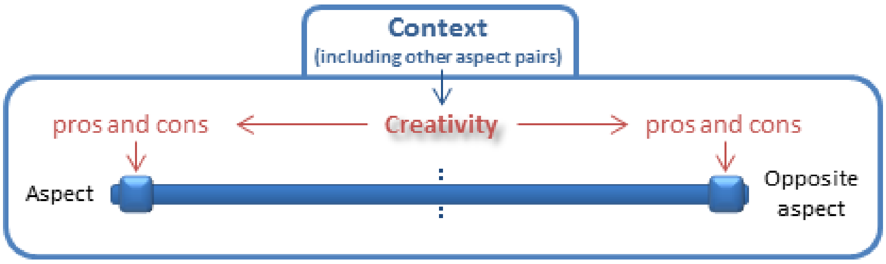


Figure 5.2.: Each aspect has its pros and cons which depend on the context

5.1. Extrinsic - Intrinsic

Extrinsically motivated people expect some kind of reward in return for their efforts (e.g., money, prestige, or ratings). Such rewards increase motivation up to some degree but not indefinitely. Excessive use of rewards can have negative side effects on creativity and may cause identification problems with a particular activity or project (Deci, 1971; Amabile, 1993).

> *A variety of extrinsic constraints and extrinsic motivators can undermine intrinsic motivation and creativity, including expected reward, expected evaluation, surveillance, competition, and restricted choice. (Amabile, 1996a)*

Intrinsically motivated people define their own problem statements. They are driven by their passion and want to make life more convenient. They are usually more willing to learn and to overcome obstacles.

> *[...] learners don't mind activities that are hard as long as the activities connect deeply with their interests and passions. (Papert, 1993)*

Extrinsic and intrinsic motivation also influence each other; their transition is usually smooth.

> *However, rewards can actually enhance intrinsic motivation and creativity when they confirm competence, provide useful information in a supportive way, or enable people to do something that they were already intrinsically motivated to do. (Amabile, 1993)*

Intrinsic motivation is more difficult to achieve because project goals are often matched to the interests of several stakeholders. It's particularly hard to find a subject or opinion which is equally shared by everyone in an interdisciplinary team due to the different interests of each domain.

Agile developers are mainly driven extrinsically because they implement requests given by their customers. However, extrinsic goals don't necessarily exclude intrinsic motivation. Agile projects also offer room for intrinsic interests due to autonomous teamwork and democratic decision making. Since agile developers are supposed to improve the working conditions of their customers, they are usually given some leeway to come up with own ideas. Working with people of foreign domains or being challenged by somebody else's problem are often further intrinsic motivators.

5.2. Theory - Practice

How much knowledge is necessary to start work? Should the principles be taught first or should people learn them by doing?

> *Rather than [...] "thinking hard", we wanted them to (for example) make a series of prototypes as part of the process. Thus, we wished to not only allow bottom-up design, but to encourage it. [...] top-down design is so heavily favored in academic circles [...]. (Martin, 1994)*

The perfect compromise between theory and practice depends on the particular situation and people. Maybe the best approach is to prepare people for autonomous and collaborative work. Autonomous people are able to assess what they need to know and when they require aid. Collaborative people don't just add to their own knowledge but also share it and thereby stimulate other people.

> *"Get them going and get out of their way" [...] To accomplish this, we analyzed the shortest route between getting the kit of raw parts and getting over the barrier of understanding the basics [...] after which they would be free to manage their own progress. (Martin, 1994)*

In interdisciplinary projects, people have to become familiar with other domains first. This is also true for agile developers who have to learn domain-specific concepts from their customers. Agile developers make decisions autonomously but in accordance with their customers' needs. They continuously assess these needs by iterative prototyping. Diverse knowledge of frameworks, languages, and technologies help agile developers in this process because it increases their chances to quickly come up with proper solutions. "The more versatile skills, the better" might be a general rule of thumb, perhaps because more skills give more choices to be creative (Amabile, 1996a). That's also why further training is of general importance for creative work.

5.3. Instruction - Autodidact

Ruscio and Amabile (1999) distinguish three kinds of instruction: algorithmic, heuristic, and no instruction. Each kind has it pros and cons. The key is to challenge but not to overwhelm.

> *Too often, designers and educators try to make things "easy" for learners, thinking that people are attracted to things that are easy to do. But that is not the case. [...] people become most deeply engaged in activities that are challenging, but not overwhelming. (Resnick, 2006)*

People who receive detailed, algorithmic instructions overcome obstacles faster because such instructions prevent them from reinventing the wheel and making mistakes. But they miss self-made experience which provides the best long-term learning effects. Similar results are another drawback of these instructions. Giving no instructions at all challenges people to come up with own ideas and give them more leeway to experiment. This increases identification with one's work and opens opportunities for self-development.

> *[...] the old design education focuses on teaching the materials, tools, and techniques of design as the primary subject matter [...] the new course focuses on projects and problems that are situated within the experience and motivation of students. (Buchanan, 2001)*

Interdisciplinary projects require instructions to some degree because everyone depends on each others' expert knowledge. The complexity of multiple, combined domains make it almost impossible to train generalists who are able to work on their own without any instructions. Agile developers are given "instructions" by their customers. Within their domain, agile developers learn and work autonomously though. Customers rely on agile developers that quality software is delivered[2]. Interdisciplinary teams are interdependent: each domain relies on each other.

5.4. Support - Autonomy

Support is needed to obtain necessary information, resources, and workforce. However, support implies dependency on stakeholders who eventually influence ideas and creative work. Support gives more opportunities but also requires a fair balance of interests in order to avoid loss of identification and motivation. Autonomy, on the other hand, is a high goal in terms of creativity because no external interests have to be considered. Complexity, lack of skills or resources, and multiple stakeholders make it difficult to achieve autonomy under real-world conditions though.

Interdisciplinary teams are interdependent and thus rely on support. Know-how is distributed across multiple domains. Autonomy can attenuate interdependence to some degree,

[2] Please note that professional software development already includes certain instructions like assertions, coding standards, or test-driven development (Fowler, 2004).

for example, by learning the principles from another domain, but it's very unlikely that experts become interchangeable across different domains. Agile developers, in contrast, are supposed to have nearly equal knowledge making them very interchangeable. While customers provide the financial means and problem statements, agile developers remain autonomous in their field of activity which is the technical implementation. This autonomy allows them to come up with creative solutions even though the goals are expressed by their customers.

5.5. Simplicity - Challenge

Challenge manifests itself in countless constraints (see also 5.12) such as lack of resources, high level of difficulty, or time limits. These examples indicate that challenge depends on the particular individual and circumstances. The "right" challenge should motivate one to overcome the given constraints without the use of well-known standard solutions. Mastering such a challenge should feel like a victory. If a challenge isn't well-balanced, like continuous pressure to perform or too much workload, it can easily hamper creative thinking and distract people from solving their main objectives. A good example for adequate challenge is today's robot development. Annual contests are hosted by DARPA[3] or ELROB[4] where robots have to solve well-defined problems. Advancement is made on every new event and each time the problem statement is adjusted accordingly. Simplicity, on the other hand, makes things easy so that novices are able to get quickly started. This is commonly achieved by providing proper support, for example, operational workbenches, detailed instructions, or sufficient resources. Simplicity gives people more time to work on certain problems whereas other problems have been managed for them. However, if things become too simple, people easily get bored and unmotivated which in turn reduces creative thinking. All in all, finding the perfect trade-off between challenge and simplicity is a complex matter and depends on the individuals and circumstances. The guiding principle "easy to learn, hard to master" summarizes this conflict.

Making the simple, awesomely simple, that's creativity. (Charles Mingus)

Many challenges exist in interdisciplinary work like the allocation of responsibilities, opposing interests, or additional communication efforts caused by multiple cultures and domain languages. Agile developers have to learn the specific language of their customers too. Moreover, agile developers make heavy use of software tools to simplify work, especially routine work, for example, code completion, unit tests, or continuous delivery.

[3] See http://www.theroboticschallenge.org
[4] See http://www.elrob.org

5.6. Individual - Team

Individuals who pursue their own goals are very dedicated. They can make quick decisions and thus good progress because they aren't distracted by any collaboration activities.

> *[...] the performance of individuals is generally superior to that of groups. But some investigators have speculated that this pattern of results may have been driven by the specific experimental tasks, concepts, and research methods employed. (Amabile and Hennesse, 2010)*

On the other hand, individuals need all the knowledge and skills in order to implement an idea on their own. This is primarily feasible for autodidacts and smaller goals.

> *Rather we favor what one might call the Leonardo model. We encourage individuals to transgress traditional disciplinary boundaries and learn to function in whatever fields of knowledge they need to accomplish their goals. (Ellen and Gross, 2007)*

A common problem is that most individuals lack the necessary skills, time, or resources. A team, in contrast, can distribute knowledge, resources, and workforce among many people. However, this comes at the expense of additional coordination and communication efforts which are often underestimated (Hackman and Morris, 1975; Maier et al., 2007). A lot of trouble is based on understanding problems, especially in interdisciplinary teams, because each domain uses special languages and has a different way of thinking. Separation of responsibility is another problem. In the preliminary studies, some teams separated their work in such a strict way that it caused a counterproductive working atmosphere: "Don't ask me, I'm not responsible for that!". Nonetheless, interdisciplinary teams still offer more opportunities and diverse results.

> *In both of these investigations, group work was found to produce better results on various measures of creativity (fluency, flexibility, and originality), but total fluency was higher for study participants working alone. (Svensson et al., 2002)*

The more diverse (the more domains work together), the higher the risk of suppressed ideas. People usually want to conform to group norms and may then ignore unorthodox ideas (Amabile and Kurtzberg, 2001). Opposing interests between domains fortify such suppression even further. It's a great challenge to set up the right organizational and personal measures in order to prevent internal rivalry and to create a cooperative team spirit. Crucial factors for creative performance in groups are cohesiveness, communication patterns, group size, group composition, group diversity, group longevity, group structure, leadership, and resource availability (King and Anderson, 1990; Payne, 1990).

Maintaining the momentum is another important factor (see 5.14). If a team gets stuck due to opposing interests, it may cause endless discussions. Being able to resolve such stalemates quickly is an essential ability of a team. A coach, leader, or tribunal may aid in resolving team conflicts. Agile teams handle most of the described issues by the following rules:

- Customer collaboration over contract negotiation
- Daily stand-up meetings and face-to-face communication
- Each agile team member ...
  - has equal rights
  - is an interchangeable generalist
  - participates in the decision making process
- Small teams (about seven people)
- Someone is appointed who takes care of organizational affairs
- The source code is shared property

5.7. Roles - Equality

Roles and responsibilities are usually separated in such a way that they barely overlap. The general goal is to improve workflow within a team. However, a clear separation is hard to achieve in interdisciplinary teams because interdisciplinary teamwork is often too intertwined; an uneven allocation of roles and responsibilities is almost inevitable. In preliminary studies, some designers used engineers rather as subworkers than as partners because the designers had little technical knowledge and couldn't assist the engineers who in turn stayed out of the design process since it wasn't their responsibility. In the end, both designers and engineers were frustrated by this situation. All in all, they both didn't understand each others' needs and interests. In retrospect, it seems that common goals and common interests are an essential requirement of interdisciplinary teams. Although the allocation of roles and responsibilities is necessary, it tends to increase the risks of tearing interdisciplinary teams apart.

Agile teams, in contrast, combine roles and equality. There are at least three roles defined in agile projects:

1. Agile developers who implement the user stories
2. Customers who provide the user stories
3. Coaches who protect the agile developers from impediments (e.g., Scrum Master)

Agile developers work within the field of their customers' domain but their responsibility remains the technical implementation. Customers don't interfere in this regard. Each agile developer is preferably an equal generalist and takes part in the decision making. All in all, agile developers and their customers share a common goal: find a solution that fits the customers' request.

5.8. Cooperation - Competition

Cooperative people help each other by sharing feedback, knowledge, and work. This mutual support improves creativity in general (Amabile and Kurtzberg, 2001). Progress may either increase or decrease depending on the required communication and coordination efforts. Competition, like a contest, can increase creative thinking too but in a very different fashion: people, who compete with each other, try to be better than the rest. This kind of challenge gives them a reason to exert themselves. The prospect of rewards may be an additional, extrinsic motivator. However, competition tends to promote undesirable behavior, like hiding information or refusing aid, which prevents the exchange of ideas. This may affect the working atmosphere in a negative way, but it may also result in more diverse solutions. Interdisciplinary projects are very prone to rivalry if each domain works on its own - the lines between the domains can act as predetermined breaking points.

> *[...] team diversity can just as easily lead to negative as to positive outcomes. (Mannix and Neale, 2005)*

Agile projects aren't competitive at all because cooperation is highly appreciated, especially between customers and developers.

5.9. Focus - Diversity

An idea reduced to its essence is easier and faster implemented because less decisions have to be made. However, there is the risk of uniform results due to limited perception. Beyond that, focus can also be understood as the opposite of multitasking where people get less distracted by too many simultaneous activities. Diversity, on the other hand, includes different point of views, lateral thinking, randomness, and unusual combinations. It's about taking a special delight in differences and being open for a wider range of opportunities. Diversity can be achieved by mixing, for example, age, cultures, domains, education levels, environments, gender, skills, or languages (Leung et al., 2008; Maier et al., 2007; Resnick et al., 2009b). And yet, various studies find no strong correlation between diversity and creativity.

> *Indeed, a recent review of the literature on this topic suggests that team diversity can just as easily lead to negative as to positive outcomes. (Amabile and Hennesse, 2010)*

Nonetheless, the exchange of different domains, like in interdisciplinary teams, tends to result in more diverse ideas. Due to their diverse nature, interdisciplinary teams have also more opportunities at their disposable in order to realize ideas. On the other hand, diversity makes it hard to come to an agreement if goals, opinions, and views are a long way away from each other.

> *[...] although cognitive diversity may be beneficial for objective functioning, it may be detrimental to team satisfaction, affect, and members' impressions of their own creative performance. (Kurtzberg, 2005)*

Agile teams focus on the technical implementation. They get an insight into their customers' domain but not vice versa.

5.10. Routine - Diversification

Routine ensures a smooth process since everyone knows what to do. Automatism and standard solutions are common indicators for routine. Routine is usually best suited for simple, recurring tasks. It's a sign of best-practice and expertise which are also needed for being creative. However, phrases like "We've always done it this way!" may indicate a restriction in creative thinking. Moreover, routine can cause habituation: people lose their interest and motivation over time.

The goal of diversification is to inspire people by stimulating various senses such as imagination, kinetics, smells, sounds, tastes, thoughts, and visuals. The more the same idea is reused the more it deteriorates: first it's unbelievable, then nice, then normal, and finally unnoticed. People work likewise regarding behavior and thinking. New impulses are needed to stimulate new ideas. However, too much diversification easily leads to confusion and distraction. Diversification tends to work best if accompanied by extra time for incubation.

Agile methodologies are a mix of routine and diversification. Work is scheduled in iterations and meetings. This provides a general routine independent of the particular project. Diversification is provided by working with customers of different domains on different projects.

5.11. Predictability - Adaptivity

Creative work tends to be unpredictable because goals and ideas might change at any time. On the other hand, predictability eases scheduling and reduces project risks; it implies that either assumptions of the future are made or deviations are prohibited. Once something unexpected occurs, adaptivity is needed to respond to the new situation properly. This sounds easy in theory, but adaptivity isn't always possible or desired. People have to adapt their behavior too, but it's usually hard to change familiar behavior.

Agile methodologies make use of iterative prototyping and frequent feedback to adapt to changing requirements. Short iterations make it easier to schedule the next tasks because less prediction is necessary.

5.12. Constraints - Free space

Countless manifestations of constraints exist like aesthetics, costs, goals, resources, safety, scope, specifications, time, toolsets, or quality. Constraints have a huge impact on creative work because they affect the scope of possible results. The challenge to overcome constraints can improve creative thinking as long as the constraints aren't too restrictive.

> *Unfortunately, many managers [...] keep resources tight, which pushes people to channel their creativity into finding additional resources, not in actually developing new products or services. Amabile (1998)*

Constraints also influence each other like in the project management triangle in which cost, time, and quality stand in conflict to each other (Institute, 2010). In general, it's complicated to find a proper trade-off: the amount of constraints needed to increase creativity depends on many factors such as available resources, environmental conditions, goals, people, and their capabilities (Glück et al., 2002). Granting free space, like open problem statements described in section 2.2, provides more opportunities but may lead to randomness, inefficiency, or unpredictability. Interdisciplinary projects usually require more time because of additional communication and coordination activities. Another constraint are opposing interests which imply also additional negotiations.

Agile projects are either driven by iterations or tasks. Anyway, time is the main constraint since the basic concept of agile methodologies is to deliver usable prototypes in time so that customer feedback is gained as soon as possible. Agile developers are bound to the request of their customers but also free in its implementation.

5.13. Systematic - Flexibility

A systematic process (workflow) follows a narrow and precharted path. Tasks are scheduled in such a way that bottlenecks are minimized. Planning far ahead helps to calculate risks and to discover necessary resources, but assumptions about the future are necessary as well. If an unforeseen event occurs, flexibility is required. Rigid project units, static schedules, or strict protocols won't help then.

> *However, creativity is undermined unintentionally every day in work environments that were established – for entirely good reasons – to maximize business imperatives such as co-ordination, productivity, and control. (Amabile, 1998)*

Flexibility requires little structure which makes a project more undefined. Tasks are rather open-ended than straightforward. People act as they see fit on an ongoing basis and react to the situation.

> *If discovering the steps is part of the task, then the task is heuristic. Basically, these are things that you do, when you don't know what to do; that is, when the task is heuristic rather than algorithmic. (Amabile, 1996a)*

Planning ahead may result in wasted effort, especially in a creative work because ideas emerge and disappear frequently. However, the absence of plans and structure is usually associated with loss of control including inefficient operations, idle states, and unpredictable outcomes. Establishing structure fixes this but huge efforts and high resistance are most likely if not all relevant people are involved in this change process. All in all, it's very difficult to organize creativity in a systematic way (Johnson, 2010). It should be more about paving the way for creativity so it can flourish naturally by providing the adequate conditions adapted to the needs of the particular goals, people, and organization.

Agile projects use a mix of both worlds: tasks are frequently scheduled in each iteration. Within an iteration, agile developers are free to coordinate their work on their own - usually by daily stand-up meetings. Moreover, hierarchy is kept plain and bureaucracy is kept to a minimum.

5.14. Progress - Incubation

Amabile and Kramer (2011) state that making progress is an important factor for a creative workflow and enhances motivation among all project members. By maintaining the momentum, everyone knows what needs to be done. Furthermore, time limits are very important because they can prevent people from being lazy. Nonetheless, people get stuck from time to time because they have to come up with a solution first. In order to find a proper solution, people need to rest and they need time for diversion (Hussy, 1998). Duncker and Lees (1945) coined the term *functional fixedness*: people usually class an object with a (fixed) function which has to be changed in order to find a solution. New ideas emerge only over time or while one is doing something completely different. That's why most design processes set extra time aside for incubation. The key question is how much time is needed for incubation (Amabile and Kramer, 2011)? There is no general answer to this question, it depends on the particular project.

Incubation time doesn't exist in agile methodologies. Time is scheduled in such a way that agile developers work only on their project goals to their full capacity. Some companies like Atlassian or Google allow their employees to take one day off to do experiments unrelated to their normal work, however, this isn't a regular part of agile methodologies.

5.15. Feedback - Ego

Frequent communication is necessary within a team to agree on the next goals, to distribute tasks, and to avoid misunderstandings (Dow and Taylor, 2008). This includes also feedback, a creative factor, that motivates people, spreads different point of views, induces people to reflect on their work, and gives one a sense of how well an idea is recognized. Above all, it's very important how feedback is delivered (Zhou, 2008).

> *Not only did this type of forum provide students with valuable ideas and feedback, but it gave them a sense that their community cared about the work they were doing. (Martin, 1994)*

On the other hand, frequent feedback can be very time-consuming. The more people are involved, the more time is needed. And feedback isn't always the best way to come to terms. In order to keep people motivated, they also need to think that they are working on goals and ideas that they created or at least co-created. In regard to progress, it's sometimes necessary to let people have their own way. Constant feedback might cause self doubt if one is always taking all other opinions into account - too many cooks spoil the broth. It's also frustrating to find a perfect solution that suits everyone but doesn't exist. Moreover, feedback might affect ideation in a certain, one-sided way if it comes always from the same person or source.

In interdisciplinary projects, frequent feedback reduces the risks of misunderstandings caused by different domain-specific languages. That's also the reason why agile methodologies rely so heavily on frequent meetings, face-to-face communication, and iterative prototypes. All agile team members have to agree on the next tasks but each one still has room to determine how to implement the assigned task.

5.16. Evaluation - Playground

Evaluation has a huge influence on people's behavior and motivation. It controls the creative outcome indirectly: people try to comply with the qualities that are measured. So, they subsequently produce more predictive and similar results. If certain qualities are hard to measure or too distinct to compare, a jury is used instead, but the effects remain basically the same. Having no evaluation at all reduces motivation if people get the impression that their work isn't valued properly. A playground without any evaluation grants people the most freedom but calls for self-dependence and trust in addition.

Agile methodologies try to evaluate projects by productivity and customer satisfaction (Fowler, 2003). For this, agile developers identify the qualities that are most important for their customers and then estimate how long it takes to implement them.

Interdisciplinary projects are much harder to evaluate because each domain weights qualities differently. The problem is to agree on common qualities and measurement methods. Separate evaluation by each domain isn't an ideal solution because it doesn't reflect the project as a whole. And even if evaluation across all domains is possible, it is very likely that such a generalized evaluation will lead to false conclusions (Fowler, 2003). All in all, evaluation mostly acts like a constraint. It should be used carefully and intentionally.

5.17. Success - Failure

Failures are an inevitable part of a creative process. If stigmatized, failures kill creativity because people won't risk anything different or new.

> *I don't mean to say that being wrong is the same thing as being creative. What we do know is if you're not prepared to be wrong, you'll never come up with anything original. (Robinson, 2006)*

The need for success is often accompanied by ambitious goals, high expectations, and perfection. If success means constant growth - being always "faster, higher, stronger" - it then leads easily to permanent disappointment and discontentment with one's own results. Such a performance-oriented mantra shouldn't be the ultimate goal, especially in terms of creativity.

> *Vulnerability is the birthplace of innovation, creativity, and change. (Brown, 2012)*

Instead of preventing failure at any cost, people need to play, experiment, and venture in order to learn. A key premise is that they feel safe and know that there are no serious consequences.

> *Psychological safety is crucial for creativity in organizations because creativity involves so much risk-taking, experimentation, and frequent failure. (Edmondson and Mogelof, 2006)*

Agile methodologies are designed to discover erroneous trends as soon as possible. That's why prototyping and short iteration cycles are used. Failures are allowed but avoided as far as possible. In interdisciplinary projects, failures are often a catalyst for disputes between different domains. The question of guilt can become omnipresent and mask the actual reason for the dispute like bad working conditions, false requirements, or poor communication (Cerpa and Verner, 2009).

5.18. Sustainability - Efficiency

Sustainability is about reflection and conserving experience, results, or used materials for future generations. In terms of creativity, each preserved result acts as a further source of inspiration - Albert Einstein once said: "The secret to creativity is knowing how to hide your sources.". The more experience is shared, the higher the chances that efficiency and quality will improve. Sustainability is best accomplished by documenting and publishing the results. However, documentation, exhibitions, maintenance, and storage increase costs and prevent the reuse of physical materials. Furthermore, creative work tend to produce transient results which is why documentation becomes quickly obsolete and is often disproportionate because it distracts people from further experiments and doesn't guarantee much benefit in the short term. Regular reflection is another important part of sustainability. It covers the analysis of the status quo which should lead to measures to improve the existing working conditions. Reflection can also extent imagination and creative ideas.

Agile developers reflect on how to become more efficient at regular intervals. For this purpose, some agile methodologies define concrete strategies like backlogs and burn down charts. Meetings are frequently hold to exchange ideas, to discuss problems, or to reflect on past iterations. Preservation is done by saving all revisions of the source code and configuration files in a shared data repository. Documentation is embedded in the source code and shared over a web platform.

In interdisciplinary projects, different documentation strategies exist and need to be merged for the purpose of collaboration. Different domain languages and technical documents make this very challenging. For example, UML diagrams are used by computer scientists but such technical documents are of little use if people from other domains cannot read them. A common language for documentation is needed like, e.g., user stories in agile methodologies. Such common documentation implies that it's shared across all domains and not kept secret within a single domain.

5.19. Humus - Clinic

A creative environment (humus) nurtures diverse thinking, spreads ideas, and provides everything necessary to be creative. It requires an organization that is built on flexible, non-restrictive rules defined by all relevant people, not by the superiors. This concept can be extended to the ambiance and environment as well, both should make people feel comfortable and safe - not please the interior designers. Relaxation areas, like coffee bars, allow people to rest and have spontaneous meetings. In terms of creativity, the interior should invite people to play and reflect. This may be achieved by non-functional elements as well as less care on efficient paths and workflows. Concrete measures depend on personal preferences and the particular culture of the organization. It may be colorful with fancy interior and unusual shapes for example. Moreover, a creative environment should offer room for experiments including various technologies, tools, and resources. A clinical environment, on the other hand, is designed to be functional and supports an efficient, undisturbed workflow. The interior only contains the necessary, it's mostly plain and minimalist.

Some agile methodologies specify practices such as coding and documentation standards, software tools, or regular meetings. However, specifications about the interior design rarely exist. The most common one is supporting face-to-face communication.

5.20. Exemplary conditions

All presented aspects need to be adapted to the particular project. There is no set of conditions that suits any possible course or project. The more concrete the particular event, the more conditions can be specified. The following exemplary set of conditions presumes that a mix of various people form a self-organized team and create their common goals. This usually starts with people from different domains who meet one another, for example, at a fair, presentation, or meeting. After they have exchanged ideas, they may form a small project team based on common interests. There is no request for proposal and there are no customers. However, customers or end users may become important later in order to gain objective feedback. Sponsors and stakeholders may be acquired to obtain the necessary resources. However, dependence on stakeholders is kept to a minimum. The team and its possible stakeholders settle the prerequisites including budget, materials, and milestones. These requirements aren't carved in stone. Detailed plans are avoided because they may change quickly. Based on this initial position, the following conditions seem to be suitable for supporting creative work in independent, interdisciplinary teams:

- No detailed project drafts (flexible and non-fixed goals)
- No customer-orientation (intrinsic interests of team members first)
- No production (prototypes instead: disposable, explorative, and experimental)
- No requirements engineering (including contracts, estimates, and specifications)
- No validation (regarding ideas and implementation, just experiments and prototyping)
- No risk management (just launch a new project on failure)
- No quality management (regarding metrics)
- No guaranteed outcome (the project can change and fail)
- No money-orientation (money isn't the base of ideas and decisions)
- Fair delivery deadlines (binding but non-critical, time for incubation and diversification)
- Little requirements (qualitative metrics instead of quantified metrics)
- Little documentation (only conclusions, failure analysis, and reflection)
- Little maintenance (mostly for long-lasting support tools)
- Little acceptance tests and usability analysis (idea first, end user second)
- Little bureaucracy (self-organized teams, no formal processes and rules)
- Little predictability (due to changing goals and unknown project outcome)
- Little material costs (proof-of-concept, prototypes, pretotypes, and simulations)
- Short-term scheduling (only the next tasks, no tasks in the far future)
- Short project duration (only quick proof-of-concept and feasibility check)
- Small, self-organized teams (easier decision-making, less coordination)
- Some analyzing (reflection on status quo, external coaches may aid in this regard)

- Some external dependency (influence of stakeholders is minimized though)
- Some diversification (attending exhibitions or talks, external stimulus)
- High cooperation (no contest and no evaluation within the team, equality)
- High participation in decision-making (intrinsic motivation)
- High frequency of meetings (informal coordination, feedback, reflection)
- High diversity (creativity techniques, much materials and resources are available)
- High availability of personnel (coaches, experts, and people all from different domains)
- High adaptability (no fixed project entities, processes, and structures)
- High use of prototyping (experiments, proof-of-concept)
- High favor for coaches (who collect experience, connect projects, support teams)
- High support (inspiration, technology, training, tools, materials, and resources)

Please note that ideas shouldn't be influenced by money, however, money is still very important: it enables substantial support for creative work due to less impediments in regard to personnel, technologies, training, tools, materials, and time limits.

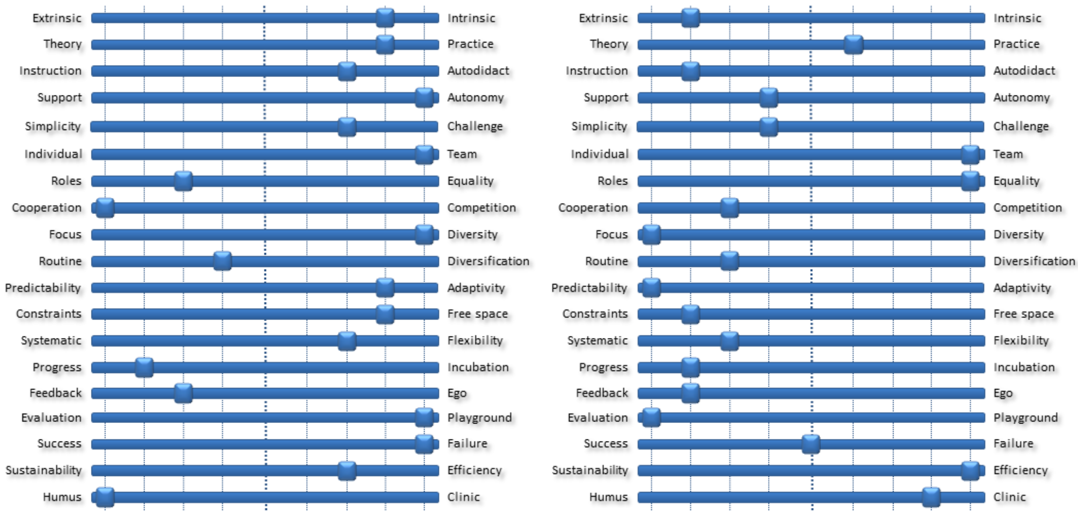
All suggested conditions were mainly pursued in the preliminary studies. They are no silver bullet nor were they ever fully applied. They rather present an ideal target in order to support creativity in interdisciplinary teams. Adaptations to the particular people and situation are still necessary. The following figure 5.3 shows how all the suggested conditions would look like if mapped to the 19 aspects pairs:

Figure 5.3.: Exemplary conditions for creative and interdisciplinary teamwork

Most of the suggested conditions are adopted from agile methodologies like coaching, frequent feedback and reflection, focus on prototyping, minimized bureaucracy, small and self-organized teams, and short iterations. Other conditions have been added to improve creativity, interdisciplinary teamwork, and intrinsic motivation. Please note that there is no statement on the allocation of team roles which highly depends on the given people as discussed in section 4.3. Conditions and people need to be well-orchestrated as well.

5.21. Comparison and patterns

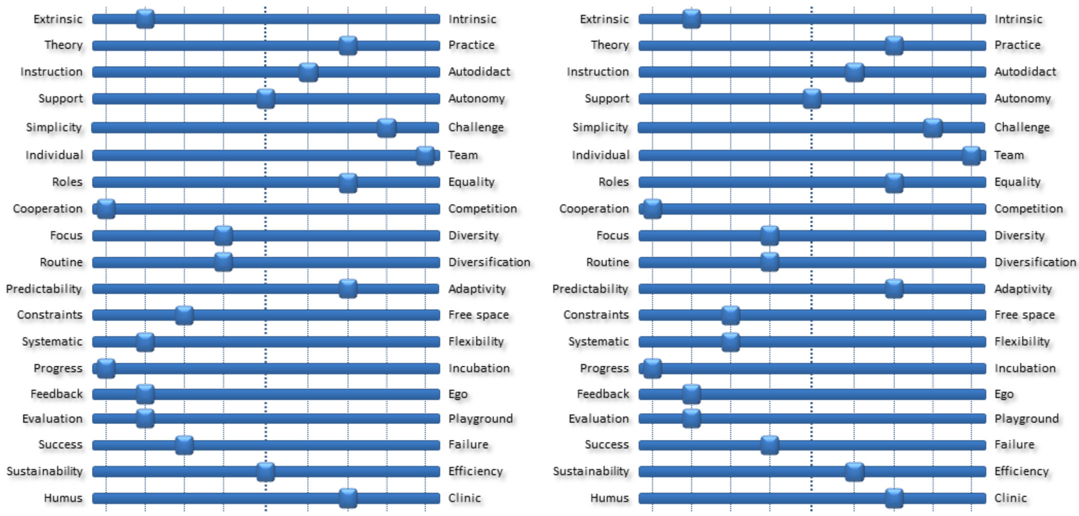
Besides designing courses or projects, the 19 aspect pairs can be used to compare existing courses. The following figure 5.4 compares two courses of the preliminary studies. The Toaster Edwin workshop was primarily designed for students who were given little restrictions, they were allowed to do what they like to do for the most part. The Margaretha-Rothe school class, in contrast, had predetermined results in order to achieve specific educational objectives in time. Before the kids were allowed to work on their own, they were taught the necessary skills in playful, but also guided exercises.



(a) Student workshop (Toaster Edwin) (b) School class (Margaretha-Rothe I)

Figure 5.4.: Aspect pairs compared on the basis of two courses of the preliminary studies

The following figure 5.5 compares the aspect pairs of two agile methodologies. They represent service-oriented projects in which specifications and requests come from customers. The figure shows that they are both very similar. However, Extreme Programming gives more instructions and tends to be slightly more structured than Scrum.



(a) Extreme Programming (b) Scrum

Figure 5.5.: Aspects pairs compared between two agile methodologies

Please note that such comparison is based on subjective ratings and highly depends on the context. For example, adding a V-Model-based project would cause a shift in the weighting of all other compared projects because the V-Model would set new benchmarks, especially in evaluation, predictability, and systematic.

Beyond that, the visualization of the 19 aspects pairs can be used to identify patterns and to define the type of a course or project. For example, courses like Toaster Edwin, in which open problem statements (described in section 2.2) are favored, tend to be more right-aligned whereas courses like Margaretha-Rothe, with a predefined outcome, tend to be more left-aligned (see the previous figure 5.4). Besides the alignment, it would also be possible to use curves to specify further types. Moreover, there are multiple aspects that seem to correlate, for example, autodidact and autonomy, clinic and efficiency, constraints and systematic, failure and playground, feedback and evaluation and success, or instructions and simplicity and support. However, the preliminary studies don't provide enough data for sufficient evidence or reliable conclusions. Further studies are necessary.

5.22. Conclusion

The aspect pairs in this chapter don't aim to be complete since their completeness cannot be proved, only their incompleteness. More empirical studies are required to reveal further aspects. Some of them can be decomposed into further aspects, for example, the aspect "constraints" could be decomposed into materials, money, skills, and time. This would provide a more accurate view but at the expense of an easy inquiry. Overlapping terms and synonyms make this classification very difficult though. Some aspects are also more relevant than others depending on the particular course or project. Once the relevant aspects pairs have been defined, they can be used to specify course and project types and to compare them. The positive and negative effects on creativity can be estimated more precisely then. This also includes possible correlations of one aspect to the others. All this requires a well-grounded data base; the preliminary studies aren't sufficient for such analyses.

Besides analyzing and comparing aspect pairs, this chapter has also shown that agile methodologies provide a flexible basis for creative work due to frequent feedback, prototyping, and short iterations. However, the focus on customers and productivity may hamper creativity in agile teams. Especially customer affinity seems to restrict intrinsic motivation and individual ideas. This is also true for teamwork in general because different opinions and stakeholders exist here which call for compromises. That's why common goals and interests appear to be a solid foundation for teamwork, it promises less disputes and faster accordance with decisions (at the expense of diversity though). In contrast to agile teams, a common problem of interdisciplinary teams is the allocation of responsibility because different domains tend to compete with each other to enforce their own ideas and interests. The question of possession - regarding ideas, materials, and rewards - is a crucial point as well. All in all, it's a complex matter to define the right mix of social, environmental, and conditional aspects - especially because they affect each other.

The sticking point is that there is no specific configuration that suits any case. Creativity cannot be forced by design: it should be naturally shaped by the given people and situation while the organization provides appropriate conditions and eliminates emerging impediments. So, maybe the best approach is to design creative projects in such a way that people are able to switch from one extreme to the other in dependence of the particular situation. This implies the need of a fair balance between all aspect pairs and being able to change them at any time. Admittedly, this is idealistic and ignores common problems like limited resources, personal preferences, opposing stakeholders, or social disputes. The upcoming chapter 6 is about methods and how they influence social, environmental, and conditional aspects. Conditional aspects are usually shaped by rules, the upcoming chapter will show that they're also shaped by the choice of applied methods and vice versa.

6. Methods

This chapter will show that each method affects and is affected by the aspects discussed in the previous chapter. Nickerson (1999) compiled the following list of creativity methods that are commonly stated or used in academia and industry:

- Building basic skills
- Building motivation, especially internal motivation
- Developing self-management (metacognitive skills)
- Encouraging acquisitions of domain-specific knowledge
- Encouraging confidence and a willingness to take risks
- Establishing purpose and intention
- Focusing on mastery and self-competition
- Promoting supportable beliefs about creativity
- Providing balance
- Providing opportunities for choice and discovery
- Stimulating and rewarding curiosity and exploration
- Teaching techniques and strategies for facilitating creative performance

The following methods comply with these methods. In addition, they're designed to improve creativity in interdisciplinary teams. For this, agile methods are used as an initial point. That's also why most of the following methods focus on adaptability, prototyping, communication, and little bureaucracy. The intended downside is limited predictability. Further adjustments address diversity, intrinsic motivation, and tolerance since these aspects are often needed for interdisciplinary teamwork. A deeper analysis can be found at the end of this chapter.

As discussed in the previous chapter 5, there are no "right" aspects that cover every circumstance. A method has rather to be chosen in accordance with the particular goals, situation, and people. Each applied method can channel creativity in a certain direction. Therefore, all of the following methods are optional although they're written in an imperative manner for the sake of readability. Some methods have stronger effects if applied in combination, such connections will be mentioned in the respective method description.

> *This approach is more educationally sound than the popularist, de-contextualised "thinking outside the box" activities or "How to be a creative genius!" books and courses. Creativity cannot be dumbed down and there are no shortcuts. (Lassig, 2009)*

6.1. Settle the prerequisites

Although fixed contracts generally tend to hamper creativity, some issues have to be settled right at the beginning to prevent awkward situations. Adjustments should still be possible during the project since creative work is very volatile.

Related to: Team (5.6) • Roles (5.7) • Cooperation (5.8) • Constraints (5.12)

Who pays?

Clarify who pays the charges, materials, or people (e.g., shared accounts or strict split-up).

Who decides?

Clarify who participates in the decision making and how decisions are made (e.g., by leader or majority rule). Also clarify what happens if decisions are disproportionately delayed and people don't come to an agreement (e.g., appointing an arbitrator, time limits).

Who owns?

Clarify the owner of the project, results, and materials including licenses and right of use (even beyond the particular project). Clarify what happens to the results and materials afterwards (e.g., dismantlement, exhibitions, storage). Clarify how possible awards and rewards are shared.

What are the common goals?

Clarify the common goals and interests of each involved project member.

What are the responsibilities?

The most difficult question in interdisciplinary projects because responsibilities are hard to separate and they may also change over time so that frequent reorganization is necessary.

How is creativity valued?

Clarify which value creativity has within the project. Is creativity an inherent part of the whole process or only appreciated in certain project phases? What significance has creativity compared to other objectives like, e.g., efficiency, productivity, or quality?

6.2. Open atmosphere

Foster creativity by establishing a pleasant atmosphere that is lived by its people, not hold up by force and rules. Please note that various factors exist to measure atmosphere (see appendix C on page 121).

Accept failures

Creativity, especially in groups, requires safety and trust (Edmondson and Nembhard, 2006). Allow people to make failures and experience. Restrict denunciation, disrespect, internal competition, and sanctions. For this, use guiding examples embodied by coaches (see 6.10) or leaders. Ask people: "What would you attempt to do if you knew you could not fail?".

Related to: Autodidact (5.3) • Free space (5.12) • Ego (5.15) • Playground (5.16) • Failure (5.17) • Humus (5.19)

Face-to-face communication

Face-to-face communication has some significant benefits because people are more committed and pay more attention during the conversation. This increases team spirit, ideation, and understanding. Even place the interior in such a way that face-to-face communication is naturally practiced. Trust and respect are needed so that even shy people are willing to share their ideas (accept failures). In addition, a wide range of online collaboration tools is available (e.g., voice and video streaming, remote desktop, writing and modelling tools). Such tools reduce meeting efforts and may be used to some degree as well.

Related to: Team (5.6) • Cooperation (5.8) • Focus (5.9) • Feedback (5.15) • Failure (5.17) • Humus (5.19)

Creative environment

A creative environment isn't dull. It's rather a vivid organism that changes over time (e.g., color schemes and interior). The following bullet points provide some suggestions (see also room setup in section 2.3 on page 8):

- room to experiment
- room to socialize and to cultivate social contacts (see also forge links in section 6.11)
- room to relax and retire (e.g., easy chairs, flowers, music, sofas, wide windows)
- room for sports and play (e.g., board games, billiards, volleyball field)
- stimulants that activate thinking (e.g., art and design objects, bizarre architecture, inspiring pictures, unusual colors and interior. Pixar has a colorful working rooms designed as small fantasy huts[1]. Google has wide open areas, pools, and a T-Rex fossil[2])
- opportunities to eat and drink (e.g., coffee maker, fruits, fridge, microwave, snackbox)
- natural setting (Atchley et al., 2012) (e.g, garden, natural light, sun terrace, nature)

The location and neighborhood need to be considered too. As described by Florida (2012), creative people want to be around creative people and thus are mostly pin-pointed in cities and places of divergent opportunities.

Related to: Cooperation (5.8) • Diversification (5.10) • Playground (5.16) • Ego (5.15) • Humus (5.19)

[1] See pictures on http://officesnapshots.com/2012/07/16/pixar-headquarters-and-the-legacy-of-steve-jobs/

[2] See video on http://www.google.com/about/jobs/lifeatgoogle/life-at-the-googleplex.html

Creative culture

Culture refers to enduring beliefs, norms, and values of an organization. Culture is adjusted and refined over time. Everyone takes part in this process - not only the superiors. Superiors may predefine values that represent the desired organizational identity but then they have to provide the corresponding conditions too. If values are defined, provide a description how they can be accomplished. Otherwise, they remain abstract and difficult to understood. The following table 6.1 briefly lists some exemplary values that show how this might look like. The table D.1 on page 122 contains further values recommended for creative environments.

Related to: Cooperation (5.8) • Diversity (5.9) • Adaptivity (5.11) • Failure (5.17) • Humus (5.19)

Value	How to achieve and maintain
Cooperation	across divisions, aim for common goals, co-determination, equality, flat hierarchy, readiness to help others
Diversity	interdisciplinary projects, training for lateral thinking, use of creativity techniques
Adaptivity	be and create the avant-garde, flat hierarchy, frequent revision of structures and procedures, no fix goals
Openness	appreciate foreign projects, public projects, regular visits of exhibitions, invitation of guest speakers, sharing and transparency (open documents / hardware / source / organization)
Recognition of creativity	by adequate evaluation, by meaningful work, by rewards, by supervisors, by support of intrinsic motivation
Trust and respect	failures aren't sanctioned, honesty, frequent feedback, no internal competition, respect for equipment, ideas, and people

Table 6.1.: Exemplary values that may define a creative culture

Incubation time

Find an appropriate trade-off between active and quiet periods (Urban, 2004). Don't let productivity become the ultimate goal. Atlassian or Google, for example, allow their employees to take a full day to work on a project unrelated to their normal workload. Schedule projects with additional buffer time. Schedules aren't exclusively determined by a small group of people (e.g., the marketing department).

Related to: Free space (5.12) • Incubation (5.14)

Open-ended problem spaces

Design open-ended problem spaces that lead to multiple right solutions instead of a single (familiar) solution (Martin, 1994; Edmonds and Candy, 2002). See also section 2.2 on page 7.

Related to: Autodidact (5.3) • Challenge (5.5) • Diversity (5.9) • Free space (5.12)

Open mind

People can speak freely regardless of hierarchy and social status. Ideas and people aren't rated. People don't cling to the status quo. New ideas are welcome, unusual thinking is tolerated[3], and people exchange their ideas (see 6.3).

Related to: Cooperation (5.8) • Diversity (5.9) • Feedback (5.15) • Playground (5.16) • Humus (5.19)

6.3. Tell a story

Ideas are differently valued depending on emotions, personal preferences, memories, and how they are presented. Wrapping an idea into a story makes it more comprehensible (Pink, 2006; Heath and Heath, 2007). Story telling is much more vivid than explaining an abstract outline of an idea. A banal product like a toothbrush equipped with the right story might suddenly arouse emotions, imagination, or memories. Furthermore, stories help to work out the details because possible scenarios are played through. This usually induce people to come up with further ideas. Another important factor is that people are more engaged if they tell their own story. A project becomes then personal and meaningful.

Shared story book

Keep records of the story in a non-formal story book that contains just everything: audio, blue sheets, bullet points, codes, drawings, ideas, photos, scans, sketches, or videos. In group work, this story book must be shared among all members to ensure that no one is excluded. Shared ideas inspire people to have further ideas and foster feedback. Social media platforms (like blogs, cloud storage, or wikis) help to share the story book among all team members.

Related to: Team (5.6) • Equality (5.7) • Cooperation (5.8) • Feedback (5.15) • Sustainability (5.18)

Shared story development

All team members participate in the story process, otherwise some members might feel degraded and lose motivation. The lack of common interests appears to be an important reason why creative projects fail (besides the lack of communication and resources). However, it's difficult to keep everyone involved in equal measure. Democratic decision making and

[3] Read the story of Dan Shechtman who finally won the Nobel Prize in Chemistry: http://www.nytimes.com/2011/10/06/science/06nobel.html

teams without hierarchy are viable starting points in this regard. Coaches (see 6.10), who suggest tasks according to personal interests, can be of help too.

Related to: Team (5.6) • Equality (5.7) • Cooperation (5.8) • Ego (5.15) • Feedback (5.15)

Non-formal story lines

Avoid over-specified stories. Stories almost always change in creative work. Moreover, strict specifications tend to hamper the creative process because they confine and influence possible ideas. However, an idea must be specified at some point in order to implement it: prefer scopes and qualitative instead of quantitative descriptions. Also make use of permanent prototyping (see 6.6) and short iterations (see 6.8).

Related to: Adaptivity (5.11) • Free space (5.12) • Flexibility (5.13) • Progress (5.14) • Efficiency (5.18)

6.4. Think different

Approach a problem from more than one angle. Switch layers of thinking and working by using different materials and tools for the same purpose. Consider creativity techniques (see 6.5) and interdisciplinary teams to enlarge thinking and opportunities. Develop ideas from a human-centered point of view and take different cultures, habits, and mindsets into account - this is also known as Design Thinking (Brown, 2009). Train divergent thinking and offer courses, training, and workshops. Software applications that train divergent thinking exist as well and are described in Benedek et al. (2006).

Psychological thinking

Especially engineers like to come up with logical and rational ideas. That's why they solve most problems in a technological or economical manner. But a "good" solution cannot only be measured by objective numbers - the emotional and psychological impact on people needs to be considered as well. For example, in order to reduce the time people have to wait for the next train, you can either make all trains faster or you can set up an installation on each station so that people lose track of time while interacting with it.

Related to: Focus (5.9) • Diversity (5.9) • Adaptivity (5.11) • Free space (5.12) • Feedback (5.15)

Emotional thinking

Make ideas human. Equip them with emotions, history, interactivity, or personality. Give them nicknames. The more human-like an idea, the more senses are stimulated and the more willing are people to relate to it (Norman, 2005).

Related to: Focus (5.9) • Diversity (5.9)

Contextual thinking

React in accordance with the present surroundings (Abowd et al., 1999; Dey and Abowd, 1999). Use background information to make the idea or interaction more vivid and personal, for example, find out the age, gender, name, interests, or living place of a person by using audio, internet, or visual analysis. Take the feelings into account that people have and react accordingly Picard (2010), for example, sense boredom, illness, laughter, or sadness by analyzing facial expression, mental state, or voice. Be aware of external interactions, for example, don't interrupt an ongoing conversation without purpose.

Related to: Focus (5.9) • Diversity (5.9) • Feedback (5.15)

Environmental thinking

Ask why an idea is placed in that particular location. Consider the local environment in such a way that the idea disappears into it seamlessly. For this, make use of the given architectural and natural circumstances, for example, materials, sun light, textures, or weather. Consider the local culture, inhabitants, and resources; spend time in their domain and include them in the design process, for example, making a district more vivid, entertain people, or enhance living, infrastructure, or nature.

Related to: Focus (5.9) • Diversity (5.9) • Feedback (5.15)

Social thinking

Connect people and support social interaction as described in Snibbe and Raffle (2009)[4]. Create games in which people benchmark themselves, cooperate, compete, or vote. Get people involved, give them the feeling that their actions have an impact on each other or on their environment. For example, let them decide whether they temporarily cooperate or compete with each other. Another idea would be to digitize classical games like board games or cops and robbers. By using new technologies, such games can be extended with new experience and interaction.

Related to: Focus (5.9) • Diversity (5.9)

Unique thinking

Make ideas unique. For example, police officers in the U.S. are known for their addiction to donuts. As the donuts shop was closed down in the city of Clare, local police officers bought that shop. Since then they're very successful in selling donuts under the label Cops & Donuts[5]. The donuts may not be better than other donuts but the ironic background makes them special. The point is to create meaningful stories worth remembering.

Related to: Focus (5.9) • Diversity (5.9)

[4] Examples can be found on http://www.snibbeinteractive.com

[5] See http://www.copsdoughnuts.com

Diverse thinking

Prevent routine at work or in interaction. Provide diversification. Avoid repetition. Make alternations and surprise people. Be unpredictable and unusual.

Furthermore, urge people to be open for new behavior, experiments, features, processes, technologies, and views - software developers, e.g., embrace reusability to solve problems in the same approved manner. In general, avoid fixed structures and specifications. Offer lateral thinking training and provide some distraction once in a while, for example, by going to conferences or exhibitions. Use creativity techniques (see 6.5) and take advantage of randomness to increase diversity further. Software tools can be an excellent extension for this purpose (see 6.7) and automate routine work as well. However, diversity requires people being able to cope with frequent change as discussed in chapter 4.

Related to: Diversity (5.9) • Diversification (5.10) • Adaptivity (5.11) • Free space (5.12)

Physical thinking

"Explore ideas by thinking with your hands." (Brown, 2009; Brown and Vaughan, 2009). Actually working with physical objects stimulates senses that usually lie idle. People find it much easier to attach to ideas that they can smell, taste, touch, and play with (see also romper room in section 6.6).

Related to: Focus (5.9) • Diversity (5.9) • Diversification (5.10)

Transformational thinking

Mix data, senses, states, or old ideas in all kind of possible and unusual ways. For example, chirp image data, translate the current weather to music, transform 3D into 2D or vice versa, record people and replay them accelerated, morphed, or time-delayed, compare friends with chocolate, use water as touch screen, or visualize crowds and moods. Creativity techniques and computer tools are excellent to find and generate new combinations (see 6.5).

Related to: Focus (5.9) • Diversity (5.9)

Tweak and remix thinking

Creativity doesn't necessarily require one to be a pioneer. Tweak or remix existing ideas instead. Cuisine, fashion, story telling, music, or Youtube are all good examples where ideas are remixed all the time which leads to new ideas once in a while - creativity is often influenced by trends and zeitgeist. Moreover, many ideas exist that are great but poorly implemented - make it better.

Related to: Focus (5.9) • Efficiency (5.18) • Sustainability (5.18)

Design thinking

Design is about finding a coherent combination of content and form. For example, "fear" and "FEAR" have the same content but each form carries a different message. Shape the design until it matches the idea. Augment the design with subtext and meta-level to provide depth and to stimulate thinking.

Related to: Focus (5.9) • Diversity (5.9)

Visual thinking

Use visual thinking techniques (Sibbet, 2010, 2011) by combining text, pictures and symbols to illustrate ideas or to describe processes as shown in figure 6.1. Such a non-formal visualization is particularly useful in interdisciplinary teams because everyone is able to understand them. Visual thinking acts like a common language. The drawback is that people may interpret an image differently. Close collaboration and iterative development (see 6.8) should be used with visual thinking. Prefer scopes and qualitative descriptions. Avoid domain-specific and technical documents.

Related to: Team (5.6) • Cooperation (5.8) • Free space (5.12) • Feedback (5.15)

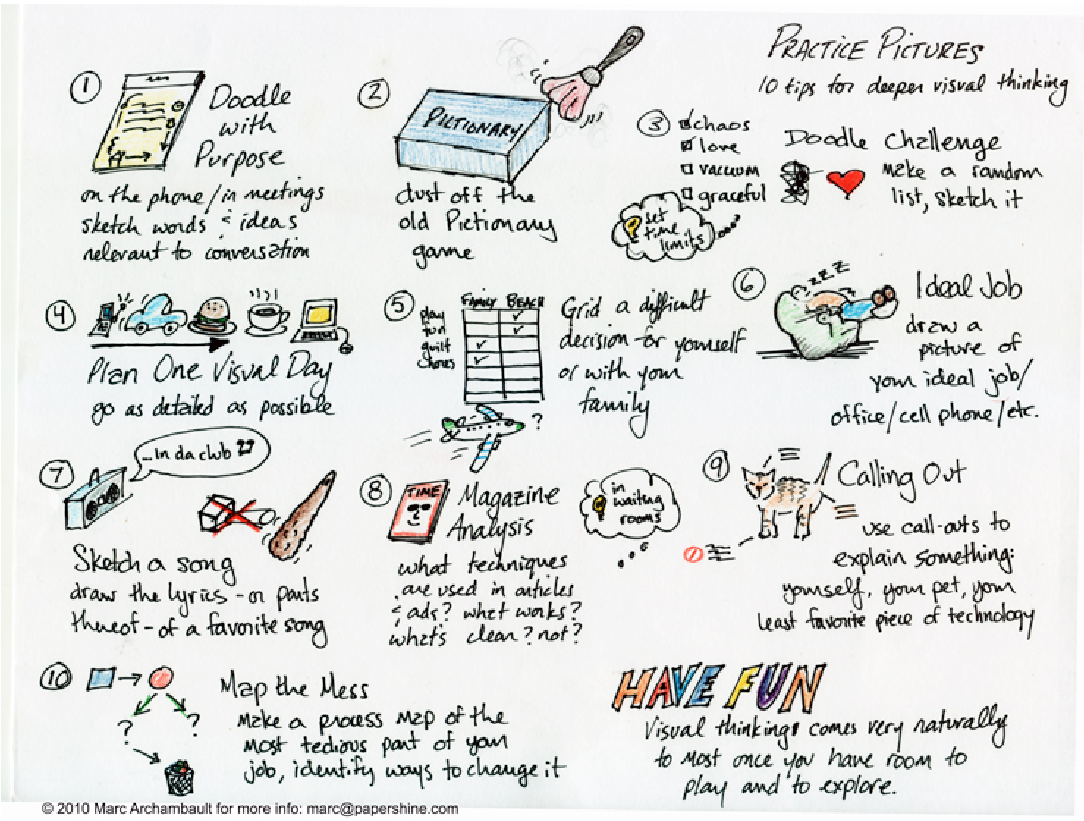


Figure 6.1.: Example of visual thinking. Source: Archambault (2010)

6.5. Creativity techniques

Use creativity techniques to break routine work, to exchange views, to gain new ideas, and to inspire people. Creativity techniques are often designed for groups, easily learned, and quickly performed since most of them are based on pen & paper. Software that implements creativity techniques, except mind maps, is still rare though.

Break the inhibition threshold

Creativity techniques are seldom used although they take only a little amount of organizational effort and aid people in shaping their ideas dramatically. There are some reasons for this:

- Most creativity techniques and their purposes are unknown.
- It's difficult to find the right technique for the right purpose.
- Due to the playful nature of most techniques, people have problems to take them serious.
- People are shy or feel uncomfortable because they have to act in an unusual way.
- Fear of proposing "bad" ideas or being criticized.

These issues can be handled by fostering open atmosphere as well as trust and respect (see 6.2).

Related to: Equality (5.7) • Playground (5.16) • Humus (5.19)

Use creativity techniques frequently

Reduce the inhibition threshold by frequent use of creativity techniques. People should become used to them over time. It should be fun, not forced though. Use creativity techniques in any phase, not only at the beginning of a project. Explore new creativity techniques over time. Do experiments and find the necessary adjustments that suit a particular team.

Related to: Practice (5.2) • Routine (5.10)

Use multiple creativity techniques

Over one hundred creativity techniques exist. Each technique serves a particular purpose. It's essential to make use of several techniques instead of only one. The following selection presents some techniques and illustrates their possible application:

- Mind mapping and brainstorming are best suited for collecting ideas.
- Creative writing is useful to discover new ideas, properties, and features.
- Zwicky Box helps to detect unusual combinations of given properties and features.
- SCAMMPERR is a checklist of questions that helps to develop new products and services.
- Six Thinking Hats is a role playing technique in which participants learn different views.

These examples are just a glimpse of available creativity techniques[6]. Experiments are necessary to find the right technique for the right purpose and for the right group.

Related to: Diversity (5.9) • Diversification (5.10) • Playground (5.16)

[6] See more creativity techniques on http://www.mycoted.com/Category:Creativity_Techniques

6.6. Permanent prototyping

Levitt (2002) states that creativity is thinking up new things and innovation is doing new things. The issue here is that ideas alone don't sell - an idea needs a proof of concept in order to provide a sense of its potential value. This is best done by prototyping which covers experiments, feasibility, learning, and valuation. While prototyping, people usually come up with further ideas and encounter paths or problems, they wouldn't have taken into account else. Furthermore, prototyping helps people to get started in the first place.

Always disposable prototypes

Build only disposable prototypes. Avoid prototypes that become too big to fail, especially prevent that people get too attached to a prototype. Keep prototypes cheap, simple, and small. Use time limits so that people don't spend too much effort into a disposable prototype. Failures and mistakes have less impact then. This approach allows "quick & dirty" hotfixes as well.

Once a disposable prototype has proven itself and results in a product, redevelop it from scratch in compliance with all professional practices straight from the drawing board - even meticulous planning is then possible because the final product is well-known.

Related to: Practice (5.2) • Failure (5.17) • Efficiency (5.18)

Simulate prototypes (pretotyping)

Simulate or fake finished prototypes to receive a first impression of an idea. Use mechanical turks, mock-ups, photoshop, or video tricks[7]. This approach is also known as pretotyping:

> *Testing the initial appeal and actual usage of a potential new product by simulating its core experience with the smallest possible investment of time and money. (Savoia, 2011)*[8]

Related to: Practice (5.2) • Progress (5.14) • Feedback (5.15) • Efficiency (5.18)

Gain feedback and adjust

Estimate the relevant aspects by gaining feedback as soon as possible. Collect feedback by publishing prototypes early and frequently. Respond with rapid adjustments. Permanent Beta is a similar approach in which unfinished products are published right at the beginning to acquire early end-user feedback.

Related to: Practice (5.2) • Autodidact (5.3) • Feedback (5.15) • Failure (5.17)

[7] Like Elmo's Monster Maker iPhone App: http://youtu.be/-SOeMA3DUEs
[8] Further information on http://www.pretotyping.org. See also Minimum Viable Product in Ries (2011).

Do small iterations frequently

Make small iterations and instantly test the results. If people are mostly occupied with assumptions and scheduling, indetermination and uncertainty are usually the problem - quick prototypes and small tasks (see 6.8) can help to solve this. Do incremental prototyping: start at the basic level, go on in small steps, and stop as soon as the prototype represents the idea.

Related to: Practice (5.2) • Autodidact (5.3) • Progress (5.14) • Feedback (5.15) • Efficiency (5.18)

Always presentable prototypes

Keep prototypes always presentable and in a shippable state. Being always ready for a spontaneous demonstration is very useful to gain feedback, to sell and illustrate an idea, and to initiate discussions for further ideas.

Related to: Feedback (5.15) • Sustainability (5.18)

Use prototyping materials and tools

Prefer cheap and processable materials (e.g., expandable polystyrene) for physical prototypes. Acquire prototyping machines (e.g., 3D-printers). Moreover, use software tools (e.g., CAD and CAE). See appendix A for an exemplary list of tools and materials. Offer courses for such equipment and tools - there's no use in having all the "cool" gadgets, if only a few or even nobody knows how to use them.

Related to: Theory (5.2) • Instruction (5.3) • Efficiency (5.18)

Use trash

Reuse trash and old materials. Support collecting organizations like MFTA[9] or Hanseatische Materialverwaltung[10]. Visit them to get inspired and find new materials.

Related to: Practice (5.2) • Diversity (5.9) • Diversification (5.10)

Have a romper room

Provide a homelike room where people meet, get out of their routine work, relax, and are able to explore ideas spontaneously by thinking with their hands (see 6.4). For this purpose, equip the romper room with prototyping materials and tools like blocks, board games, boxes, cards, crayons, cutters, foam glue, legos, paper, paperboard, rubber, scissors, sugru, or styrofoam. Moreover, attach pictures on the walls to illustrate examples and to tell everyone subliminally to make use of the provided materials. Even allow everyone to paint the walls. Repaint a side once in a while for new drawings.

[9] See http://mfta.org
[10] See http://hanseatische-materialverwaltung.de

> *As we become adults, taking time to play feels like a guilty pleasure - a distraction from real work and life. (Brown and Vaughan, 2009)*

Place the coffee machine, comfy chairs, and tables in this room to lure people in it. Play music. Avoid an artificial look and feel, avoid a clinical atmosphere (see 6.2). A romper room is messy (some boxes for bits and pieces won't hurt though). Further thought-provoking impulses can be found in section 2.3 on page 8.

Related to: Practice (5.2) • Diversification (5.10) • Incubation (5.14) • Humus (5.19)

6.7. Build support tools

Support mock-ups and prototyping (see 6.6). If the proper tools don't exist, develop them. Indeed, this requires some extra effort but usually pays off in mid- and long-term.

Support real-time experiments

Prefer tools that give instant feedback on parameter change in real-time. Instead of text-based, prefer haptic and visual user interfaces (e.g., drag&drop, joysticks, sliders, touch, charts, or graphics). Avoid configuration files (e.g., XML) that need to be edited or source code parameters that need to be compiled before changes can be tested. Furthermore, provide tools that are able to compare results and allows to quickly save test configurations plus conclusions (see also lean documentation in section 6.13).

Related to: Practice (5.2) • Support (5.4) • Autonomy (5.4) • Sustainability (5.18) • Efficiency (5.18)

Support frequently used tasks

Build or use libraries that are configurable, hide complex algorithms, and prevent routine work. If necessary, build a visual user interface with customizable parameters to simplify usage. Support frequent used tasks, for example, the generation of communication protocols, multi-tasking, timed-events, specific inputs (e.g., test data), and smooth outputs (e.g., acceleration, control loops, or fading).

Related to: Support (5.4) • Autonomy (5.4) • Sustainability (5.18) • Efficiency (5.18)

Support creative work

Build or use software tools to facilitate the use of creativity techniques (see 6.5) and to increase randomness by mixing attributes to discover new ideas (see 6.4 and Various (2005)).

Related to: Support (5.4) • Diversity (5.9)

Support non-programmers

Empower everyone, especially non-programmers, to do experiments (Lieberman et al., 2006). Build applications that hide complex matter by offering parameters and options so that sophisticated experiments are even possible for people who don't have the fundamental knowledge and skills. For example, a visual editor for Wikipedia allows everyone to write Wikipedia-conform articles (Forrester, 2012). WAM is another approach in which user interfaces are designed in accordance with real-world metaphors (Züllighoven, 2004).

Related to: Support (5.4) • Autonomy (5.4) • Simplicity (5.5) • Ego (5.15)

Provide a running workbench

Dynamic projects with high fluctuations require a running workbench to get new people quickly started. A predefined workbench eases collaboration if all people are familiar with it. Fowler (2012a), for example, proposes such a workbench for "charity code jams" where random people come together in order to work on a continuous project.

Related to: Support (5.4) • Simplicity (5.5) • Routine (5.10) • Systematic (5.13) • Clinic (5.19)

6.8. Small next tasks

Maintain the momentum

According to Amabile and Kramer (2011), making progress is a critical factor in terms of motivation. Everyone must have the impression that the project goes on and that there is value in one's work. Use short iterations that provide many small results. Arbitrate if people get stuck or cannot come to an agreement. Make use of (fair) time limits as well.

Related to: Progress (5.14) • Efficiency (5.18)

Short iterations

Schedule the next tasks for a short time frame (iteration). Prefer iterations in the following order: hours, day, days, and at most one week. The shorter the iteration, the easier the adjustments. Short iterations automatically result in the need of splitting bigger tasks into smaller tasks (divide et impera). Small tasks can be defined more accurately and are easier to test as well.

Related to: Adaptivity (5.11) • Flexibility (5.13) • Feedback (5.15)

Schedule on a whiteboard

Put down all tasks and responsible persons on a public (digital) whiteboard. It only contains tasks that can be processed next. Completed or obsolete tasks are erased instantly.

Related to: Predictability (5.11) • Systematic (5.13)

Prioritize tasks frequently

Focus on critical tasks that have the greatest impact (Pareto et al., 1906). Prefer self-organized teams and let them decide which tasks have to be done next. If no majority is achieved, consult a arbitrator (see 6.10) to dissolve deadlock situations as soon as possible; if necessary, split the project (see 6.9).

Related to: Equality (5.7) • Focus (5.9) • Adaptivity (5.11)

Limit tasks per iteration

Limit the number of tasks processed in each iteration according to the size of the team (about one task per member). Also limit the time of each iteration as described before. If a task isn't completed in time, change the idea and make a new, simpler task or try to split it up in smaller tasks. If the idea still doesn't work out, abandon it and start a new one.

Related to: Focus (5.9) • Constraints (5.12)

6.9. Dynamic projects

Keep projects flexible to cope with high fluctuation, emerging changes, and individual needs.

Self-organized teams

Each team coordinates its work own its own.

Related to: Autonomy (5.4) • Challenge (5.5) • Adaptivity (5.11)

Open projects

Everyone is free to create, join, or leave a project according to the motto "If you are with ideas, you are in!". There is no separation across age, income, or culture. Sort people according to their personal interests. Although leaving members might kill a project, it has usually less negative effects in the long-term because intrinsic motivation is recognized properly. The 44 questions in the Team Climate Inventory may help to estimate group climate (Anderson and West, 1996).

Related to: Intrinsic (5.1) • Diversity (5.9) • Adaptivity (5.11) • Flexibility (5.13) • Failure (5.17)

Team composition by interests

Build interdisciplinary teams that cut across disciplines (e.g., art, dance, language, math, music, science, social studies, or sports). Also mix up teams in regard to age, culture, and gender. Ask people about their interests. Connect people with similar interests, let them exchange their ideas. If these ideas match or complement each other, let them become a project team.

Related to: Intrinsic (5.1) • Team (5.6) • Flexibility (5.13)

Small projects

Prefer small teams (less than seven members) to keep coordination and communication overhead low. Keep project goals small to improve adaptability in general. The less complex a project, the more quickly it's done and the less members are bound to it.

Split large projects into smaller projects. If these small projects depend on each other, assign someone (e.g., a coach) who acts as a facilitator between them. If possible, prefer independent projects for maximum flexibility.

Related to: Team (5.6) • Adaptivity (5.11) • Flexibility (5.13)

Avoid fix project entities

Don't separate a project into fix units. Keep structures and processes flexible, simple, and non-formal. Also avoid fix time frames. Exceptions may be, e.g., a daily stand-up meeting (see 6.12) or time for documentation at the end of a day (see 6.13).

Related to: Free space (5.12) • Flexibility (5.13)

6.10. Coaching

Coaches are referred as designated people who take over superordinate, supportive tasks so that project teams can keep their focus on experiments without being distracted by political or organizational impediments. In a nutshell: coaches provide challenge, support, and stimuli. Typical coaching tasks are (see also table 4.5 on page 32):

- Arrange the exchange of people between projects (dynamic projects 6.9)
- Boost the external and internal exchange of information (forge links 6.11)
- Challenge people according to their individual skills
- Encourage and motivate people (e.g., appreciation, self-efficacy, recognition, rewards)
- Ensure the procurement of necessary resources
- Give individual-centered advice (Williams and Menendez, 2007; Kaplan, 2011)
- Handle bureaucracy (e.g., contracts, paperwork, and permissions)
- Induce people to reflect (keep asking 6.12)
- Inspire people by providing thought-provoking impulses (think different 6.4)
- Monitor the abidance by the rules (e.g., open atmosphere 6.2 or prototyping 6.6)
- Observe schedules and deadlines, prevent that projects become too ambitious (6.8)
- Resolve stalemates (e.g., caused by democratic decision making 6.8)
- Settle the prerequisites, disputes, and social conflicts (6.1)

Appoint coaches

Appoint coaches officially. Pick coaches by personal skills being suitable for a supportive role as described in section 4.2. Coaching is a full-time job, therefore keep coaches out of project teams. This prevents possible bias issues as well.

Related to: Instruction (5.3) • Roles (5.7)

Coach the coaches

Train coaches in accordance to their supportive tasks (see section 4.2). Provide teaching materials for new coaches created by present coaches. Let coaches accompany each other.

Related to: Instruction (5.3) • Sustainability (5.18)

Use multiple coaches

The number of required coaches depend highly on their tasks and the number of projects they are supervising. Divide or share coaching tasks among several coaches to avoid overload.

Related to: Support (5.4) • Roles (5.7)

No authority

Coaches have a supportive function only. Projects are self-organized by their members (see 6.9).

Related to: Support (5.4) • Autonomy (5.4) • Equality (5.7)

Continuing education

Reserve time to train individuals or project teams. For example, some companies have a 4+1 rule: 4 days work and 1 day learning. Give people time to learn and experiment on their own. Provide courses and workshops. Organize talks. Encourage people to present their expert knowledge to each other.

Related to: Theory (5.2) • Autodidact (5.3) • Instruction (5.3) • Support (5.4)

6.11. Forge links

Bring all kinds of people together and let them exchange ideas, opinions, and views.

Step outside the box

Socialize with people of different areas of expertise. Attend exhibitions, fairs, lectures, research facilities, and universities frequently. Invite guest speakers who talk about new technologies and trends. Follow research groups (e.g., ACM Interests Groups or MIT Research Labs). Organize interdisciplinary exhibitions, projects, and workshops.

Related to: Diversity (5.9) • Diversification (5.10)

Make it public

Publish all projects on the internet including attempts, ideas, and progress. As explored by Nielsen (2011), public projects attract all kinds of interested people who amplify the spectrum of thinking and speed up problem solving in the majority of cases.

Related to: Diversity (5.9) • Feedback (5.15)

Provide a sharing platform

Provide a platform that enables people to share their projects, ideas, and materials like the community platform Scratch (Resnick et al., 2009a)[11]. Connect people with similar interests. For this, maintain a register that links people to their current and past projects. Moreover, provide a place where people can spontaneously meet and exchange each other (see 6.2).

Related to: Team (5.6) • Cooperation (5.8) • Diversity (5.9) • Feedback (5.15)

6.12. Reflect

Induce people to reflect frequently. Ask them about their intentions.

Amendment board

Provide a board (physical or digital) where people can pin down their complaints and ideas. These anonymous, short-texted messages are public to all other people. Everyone can mark each pinned message with a dot to express his solidarity and support. Over time, the amendment board reveals the most disturbing impediments. It also provides new ideas. And it reminds people to change and reflect.

Related to: Team (5.6) • Feedback (5.15) • Incubation (5.14)

Regular stand-up meetings

Stand-up meetings ensure continuous interchange of feedback, ideas, progress, and information within a team and between projects (Fowler, 2011). Moreover, regular meetings give people the opportunity to reflect on their work and what needs to be changed (Derby and Larsen, 2006). In order to keep efforts in reasonable limits, prefer stand-ups within the team on a daily basis and large stand-ups across multiple teams on a weekly basis. Keep stand-up meetings as short and informal as possible. Use time limits and forbid preparations like PowerPoint presentations.

Related to: Routine (5.10) • Feedback (5.15) • Evaluation (5.16) • Efficiency (5.18)

[11] See `http://scratch.mit.edu`

Keep asking

Question goals and processes on a regular basis to prevent disproportionate weight to irrelevant issues (also known as Parkinson's Law of Triviality). Coaches (see 6.10) are predestined for this job because they've the necessary distance to a particular project. Keep questions informal and casual, otherwise people might feel controlled which is not the intention here. Ask people about their intention instead: What are your goals? What would you like to do? Are there any impediments? These questions can be structured as shown in the following table 6.2.

Related to: Support (5.4) • Feedback (5.15)

	Past	Present	Future
What	What has been achieved?	What needs do be done?	What else has to be done?
How	How has it been going?	How is it going?	How can we do better?

Table 6.2.: Keep asking the right questions

6.13. Lean documentation

Documentation distracts people from their actual work. No documentation reduces maintenance, reuse, and reflection. No documentation also makes it harder for novices to learn the ropes. A trade-off is required.

Fixed time frame

Reserve a fixed time frame of 30 minutes (more or less) at the end of a day for documentation. People are then able to reflect on their day's work while still remembering it. Avoid instant documentation because it may become quickly obsolete. Delaying documentation reduces constant maintenance so that people can focus on experiments.

Related to: Routine (5.10) • Systematic (5.13) • Sustainability (5.18)

Shared documentation

Share documentation among all project members or even make it public (see 6.11). Use online platforms like wikis or blogs for this. In interdisciplinary groups, use visual thinking techniques (Sibbet, 2010, 2011) as a common documentation language (see 6.4).

Related to: Team (5.6) • Cooperation (5.8) • Sustainability (5.18)

Focus on conclusions

Document what worked, what didn't, and why. Ishikawa "Fishbone" diagrams are useful for this purpose. If a new idea comes up, document the reason why it has replaced the old one. Don't renarrate, keep conclusions short and precise instead.

Related to: Sustainability (5.18) • Efficiency (5.18)

Excursus: Ishikawa diagrams

Ishikawa diagrams are also called fishbone or cause-and-effect diagram. They are useful to detect potential factors that cause an overall effect (problem). The following figure 6.2 shows an extended version with short conclusions at the bottom.

Usage / tips:

- Start on the main (category) level
- Advance down to the next level by asking why-questions
- Keep the problem statements simple and small
- Don't mix up multiple effects, create further diagrams instead

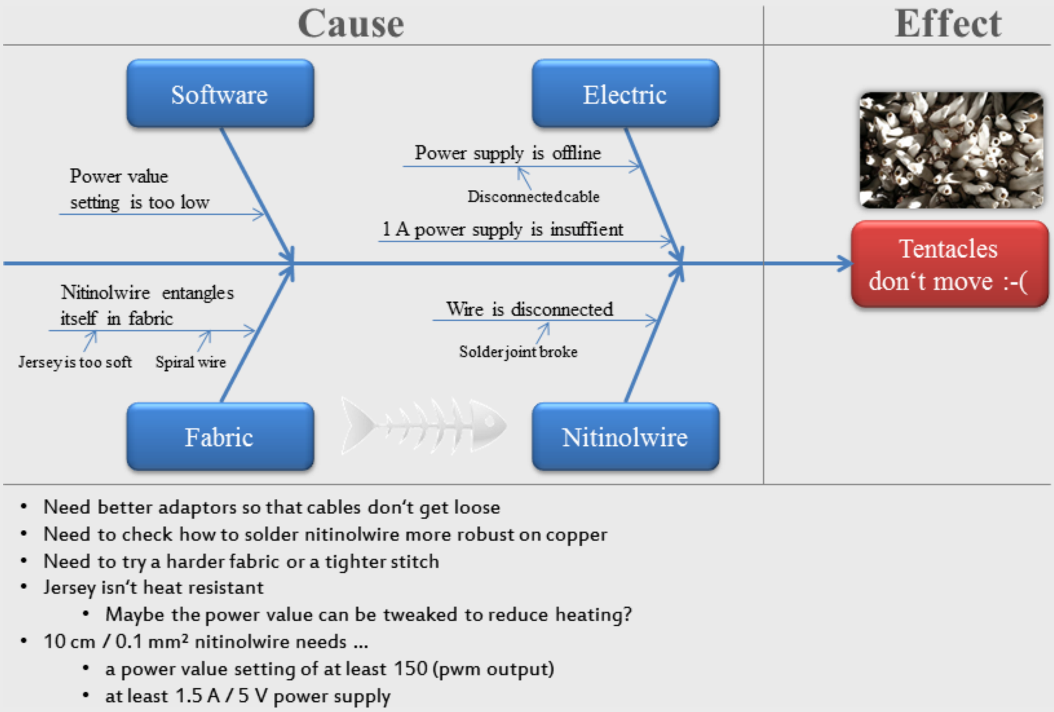


Figure 6.2.: Example of an Ishikawa diagram extended with conclusions

6.14. Origins

The methods suggested in this chapter are designed to enhance creative work in interdisciplinary teams by adapting agile methods. Each method affects agile, creative, and interdisciplinary teams differently. The following figure 6.3 illustrates their main intention and origin. For example, if a method has its origin near creativity, it's primarily intended to improve creative work. Some methods also overlap like think different, for example, which affects (or is affected by) creative and interdisciplinary work. Please note that the methods are grouped in categories to provide a better overview which comes at the expense of precision though.

Figure 6.3.: Suggested methods and their respective origins

6.15. Connections

Some methods can be more effective if they are combined. The following figure 6.4 shows an condensed overview of the most important combinations which are based on each respective method description. Most notably, the figure highlights the central and supportive role

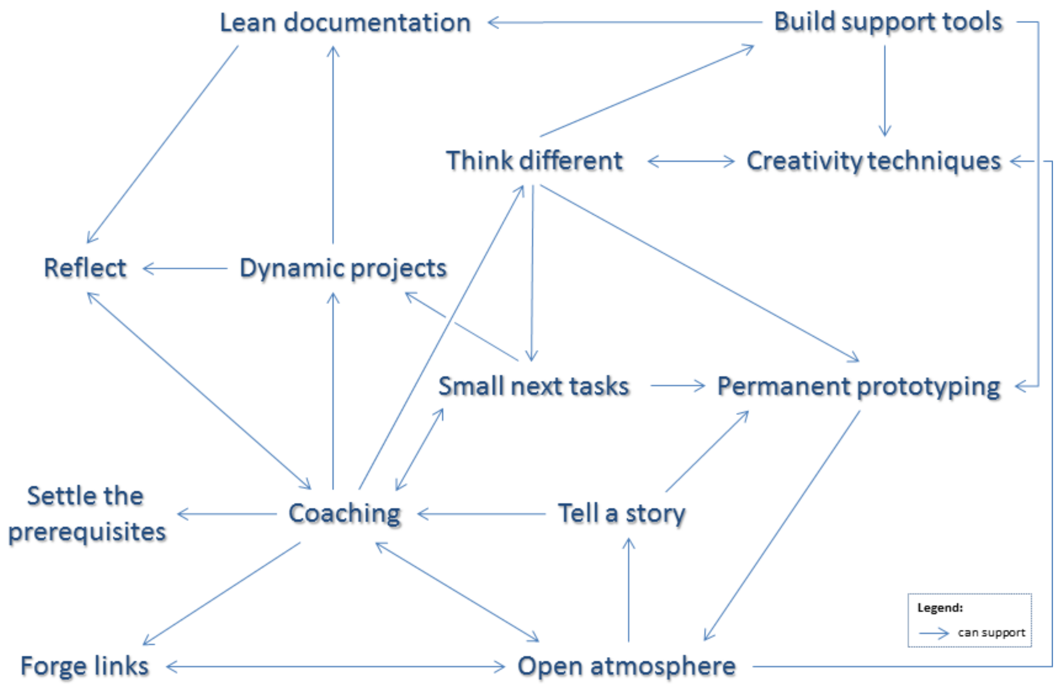
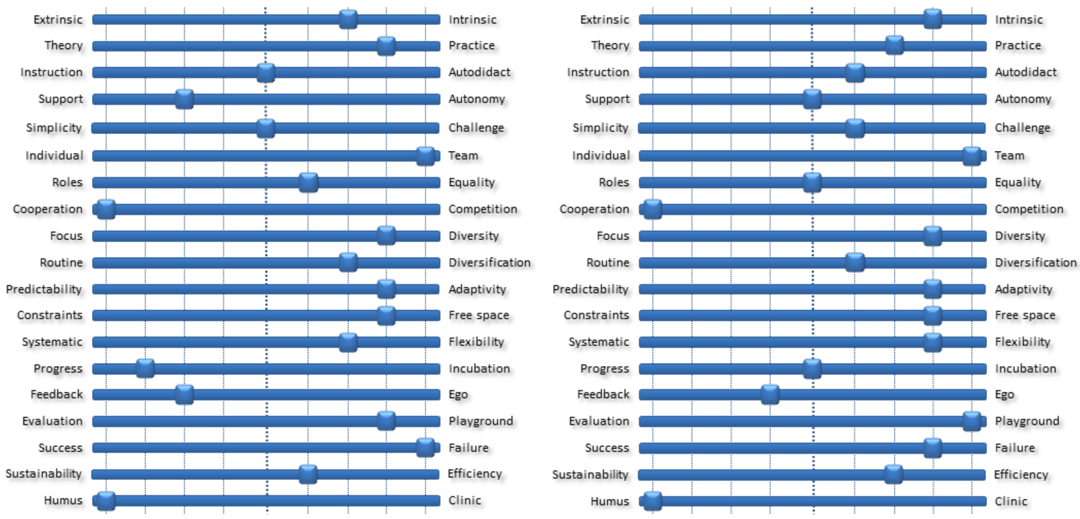


Figure 6.4.: The most important connections between the suggested methods

of coaching which stands in contrast to traditional, hierarchical leadership as described in section 4.2. The figure further reveals that build support tools, tell a story, and think different are mere supportive methods whereas settle the prerequisites and reflect need support from other methods. However, non-supportive methods like settle the prerequisites and reflect provide support in a diffused, general manner for the project as a whole. Apart from coaching, strong relationships exist between creativity techniques and think different, build support tools and think different as well as forge links and open atmosphere. All connections indicate a high potential for synergistic effects, however, they shouldn't give the impression that a method requires a certain other method. Each particular method should still be adopted and adapted only in accordance with the needs of the given conditions and people. Moreover, the preliminary studies have shown that courses with same conditions and methods can turn out quite differently as soon as a different set of people is involved.

6.16. Mapped to aspect pairs

The next figure 6.5 maps all suggested methods to the aspect pairs from the previous chapter 5. The methods are also compared to the exemplary conditions suggested in section 5.20.



(a) Mapped methods from this chapter 6

(b) Mapped conditions suggested in chapter 5

Figure 6.5.: Aspect pairs in comparison: suggested methods and suggested conditions

The figure 6.5 reveals great similarities. This isn't surprising because a large part of these conditions and methods have been concerted for creative work and interdisciplinary teams. They have been applied in the preliminary studies as described in chapter 2. This comparison itself emphasizes the point that different aspects on different levels (see context wheel) have to be taken into account in order to achieve a desired goal as discussed in chapter 3.

Context wheel from chapter 3

A slight distinction can be found in the aspect pair progress and incubation. There are many methods suggested in this chapter to improve the progress but maybe too little to provide time for incubation.

6.17. Usage

Methods may change over time depending on the particular project phase. Angle (2000) distinguishes three generic project phases shown in the following figure 6.6:

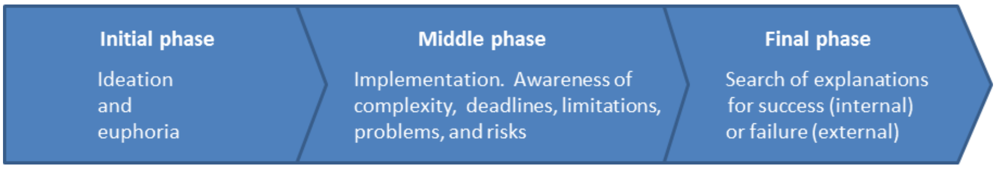


Figure 6.6.: The three generic project phases by Angle (2000)

Creativity techniques are often used in the initial phase. Subsequent phases, like implementation or distribution, often focus on efficiency and planning reliability. This separation is a reason why creativity is neglected: as soon as the initial phase is over, people get the impression that creativity isn't welcome any more (Ford and Sullivan, 2004). This applies especially to large and long-term projects. The methods suggested in this chapter are rather designed for experimental, non-critical, and short-term projects. Such projects usually don't require different phases. They are adopted from agile methodologies in which project phases are usually replaced by a continuous process. It's also a great challenge to scale agile and creative methods to large projects[12]. They both come at the expense of predictability which makes risk and quality management more difficult[13]. Moreover, agile and creative methods don't fit very well in traditional business structures that are strongly hierarchical and designed for controlling and planning[14]. Adopting them in such a context implies large cultural change first which costs much time and effort. The survey in VersionOne (2013) reveals that cultural change and general resistance to change are the most frequently named barriers to further agile adoption. Each method is only as effective as it's supported by the people and organization. A method cannot be implanted artificially by force. In general, the methods here are more suited for start-ups, R&D units, projects detached from traditional enterprise structures, and non-profit organizations like open source projects, fablabs, schools, or universities.

In order to improve creativity, it should be supported continuously and beyond any project phase. Closing deadlines make this demand difficult to fulfill though. Creativity needs to be considered right from the beginning and should be seen as an inherent part of a project. There might be two classes of methods: methods that are constantly used and methods that are only used on demand. One part of the constant methods should include creativity and coexist with the other constant methods equally.

[12] Except for the Crystal family (Cockburn, 2004): different sets are tailored to different team sizes.
[13] Additional measures may be, for example, CMMI (Glazer et al., 2008) or Six Sigma (Thomsett, 2004).
[14] Except for the agile methodology Feature Driven Design (Luca, 2001)

6.18. Conclusion

This chapter presented a choice of possible methods that can support creative work in interdisciplinary teams. Some of them are adopted from agile methodologies, some have proven themselves by experiments in the preliminary studies. All methods are still optional. Each method has its use depending on the given people and circumstance. It's more about finding the right balance between them than sticking to a particular method. The right set of methods may even change over time and with the context. In the end, there is no silver bullet. Maybe the best general method to improve creativity is to eliminate emerging impediments as quickly as possible. Coaching can play a central role in this connection. A further general rule of thumb would be to match all aspects (conditions, environment, groups, individuals, methods, resources, and skills) so that they support each other.

However, even if every aspect and method is settled and well-known, there are still many factors of fortune that influence creative work such as randomness, personal connections and encounters, or unpredictable events in economy, nature, politics, or society. For example, the incident of the whaleship Essex served as inspiration for Herman Melville's famous novel Moby Dick. Although such external factors influence people, they are beyond one's ability to plan and control. This is also connected with the question of the pursued goal: Do you want people to be more creative or do you want innovation as a certain outcome? Carefully selected methods can definitely support the first but for the latter it's only a maybe. There are no guarantees.

Many methods in this chapter have been adopted from agile methodologies, the next chapter 7 will explore them and their adaptation in detail.

7. Adaptations

Based on the methods suggested in the previous chapter 6, this chapter examines what adaptations have been made to agile methods in order to support creativity in interdisciplinary projects. The analysis starts with a selection of common agile methods and is followed by a detailed view on a chosen number of agile methodologies. Each adaptation is accompanied by a description of its intention. This chapter ends with a discussion on the compatibility of agile, creative, and interdisciplinary work.

7.1. Common agile methods

Customer affinity

The customer-driven approach of agile methodologies is replaced by an team-centered approach. First, there aren't necessarily customers in creative work. Second, a creative team should develop its own ideas and stories in order to nourish individual passion and intrinsic motivation - stakeholders, like customers, may constrain this.

Related to: tell a story (6.3)

Onsite Customer

Onsite customers (also known as whole team) make agile teams interdisciplinary. The intention is to ensure quality results in agile projects by having access to regular feedback from the customer. This is a different intention as requested in this thesis: interdisciplinary teams are expected to improve creative work and enlarge the scope of thinking and opportunities.

Related to: open atmosphere (6.2) • think different (6.4) • forge links (6.11)

Use-case driven

A use-case is a description that contains a concrete business process. Agile developers elevate use-cases from their customers in order to find the necessary specifications for the implementation. Creative teams can adapt such use-cases to tell their own ideas. In doing so, ideas become more concrete and vivid.

Related to: tell a story (6.3)

Democratic decision-making

Agile methodologies make often use of democratic decision-making. Voting ensures that each team member is equally involved in the development process which eventually improves individual motivation. Agile teams are able to come quickly to an agreement due to their small team size and common goals.

Participation is an important factor in creative teamwork too, however, democratic decision-making isn't necessarily the best or only option for creative teams. It can cause serious delays and stalemates if there is no majority. This is especially true for interdisciplinary teams where each domain usually pursues its own interests. So, a decision-maker or an arbitrator may be sufficient in creative work as long as every member shares the common vision of the team. As discussed in chapter 4, the kind of leadership depends highly on the particular project, team, and environment.

Related to: settle the prerequisites (6.1) • open atmosphere (6.2) • small next tasks (6.8)

Allocation of responsibilities

Responsibilities are separated in agile projects: customers provide the specification and developers provide the implementation. Such clear separation is hard to achieve in interdisciplinary teams because responsibilities depend on the given domains which can vary considerably. Interdisciplinary work is intertwined, hard to separate, and a further source of possible conflicts. This interdependence should be kept in mind if interdisciplinary work is up for debate. Like in agile methodologies, there should be frequent consultation to avoid misunderstandings. Unbalanced responsibilities may cause a loss of project identification as well as motivation.

Related to: settle the prerequisites (6.1)

Ownership

Agile projects are characterized by collective code ownership and product owners. Shared ownership should be used in interdisciplinary teams as well, but it might be tricky to achieve because prestige and physical objects cannot always be divided into equal parts. Unbalanced ownership may cause a loss of project identification as well as motivation.

Related to: settle the prerequisites (6.1)

Small and self-organized teams

Most agile methodologies suggest small, self-organized teams. Self-organized teams are able to develop their own ideas and decide what tasks have to be done next. It's usually more likely for small teams to come to an agreement due to a smaller number of different opinions. Furthermore, the voice of every member can be properly respected in small teams. These are the reasons why small, self-organized teams should be preferred in creative and interdisciplinary work too. For example, the more team members have to agree on one color, the more grayish will be the compromise. Compromises, be it in design or implementation, are inevitable in teamwork, but they sometimes spoil creativity. Apart from all these issues, large interdisciplinary teams still promise more opportunities because they benefit from a wider scope of expertise and thinking.

Related to: dynamic projects (6.9)

Frequent communication

Face-to-face communication and daily stand-up meetings are used in agile methodologies to gain feedback frequently. In doing so, they avoid misguided developments caused by communication errors. Interdisciplinary teams can benefit from these methods because communication errors are very likely due to the existence of different special languages. Creative teams benefit from the regular exchange of ideas. Frequent communication also helps to discover and settle engineering, responsibility, and ownership issues that may arise over time - not all issues can be settled in advance. This is especially true for creative work which is generally more unpredictable.

Related to: settle the prerequisites (6.1) • reflect (6.12)

Open work space

Besides frequent communication, most agile methodologies demand teams without hierarchy. Agile team managers still exist, but they don't lead, they rather support the team by eliminating impediments. Such passive managers give agile team members more freedom which is also beneficial for creative teams.

Since there is no hierarchy in most agile teams, trust and respect are essential in order to maintain a vital team spirit. Both qualities can be achieved by having responsible team members who work under fair conditions that don't force them into cheating. If agile team members won't trust and respect each other, it would most likely lead to blame games because nobody would be responsible for made mistakes due to the lack of hierarchy. Trust is essential in interdisciplinary teams too because it's difficult for interdisciplinary team members to assess the quality and expertise of the other team members from different domains. Trust and respect cannot prevent conflicts but they seem to increase the team spirit in such a way that teams are more able to deal with conflicts in general.

In contrast to agile methodologies, creative projects require a work space in which creativity is valued properly and not undermined by efficiency, productivity, or stakeholders' interests. This calls for an environment that attracts and nourishes creative spirits by supporting passions, by allowing creativity techniques, by stimulating diverse thinking, by avoiding routine, and by having flexible working conditions that provide adequate space for experiments and play.

Related to: open atmosphere (6.2) • think different (6.4) • dynamic projects (6.9) • coaching (6.10) • reflect (6.12)

Iteration planning

Short iteration cycles are characteristic for agile methodologies. They allow agile developers to react quickly to feedback. Short iterations are a compromise between planning and flexibility which make them useful for creative work too where ideas are very likely to change. Prototyping supports short iterations even further because it helps people to discover and understand what needs to be done. Compared to agile planning, the methods suggested for creative teams in chapter 6 are more lightweight: creative teams prioritize and schedule only the next imminent tasks.

Related to: permanent prototyping (6.6) • small next tasks (6.8)

Whiteboard

Some agile methodologies specify a whiteboard (also known as Task Board) to schedule people and tasks. A whiteboard shows also who is responsible for a specific task. Creative and interdisciplinary teams can also benefit from a whiteboard - it implies only a minimal amount of extra effort and improves collaboration considerably.

Related to: small next tasks (6.8)

Monitoring the progress

Most agile methodologies use charts to monitor the progress. Agile projects are expected to deliver a specified result in time. Charts help to adjust tasks so that work can be completed on schedule. So, charts help them to learn and to improve. Creative projects also work against the clock, but the results aren't clearly specified. Moreover, creativity is hard to measure and quantify in general. Monitoring may also influence creativity if people conform their behavior to the given metrics. All this makes it very difficult to monitor the progress of creative work. Therefore, it's questionable whether or not creative teams benefit from monitoring activities.

Related to: small next tasks (6.8)

Documentation

Agile methodologies often define certain documentation techniques like backlogs or user stories. Sharing documentation improves coordination, reflection, and sustainability regardless whether the team is agile, creative, or interdisciplinary. However, creative teams tend to produce more volatile results that make documentation quickly obsolete and hence would require constant maintenance. Therefore, creative teams should document in a delayed manner so that creative work isn't disrupted and people can focus on experiments. Documentation in advance should be avoided in creative work.

Related to: lean documentation (6.13)

Retrospectives

Retrospectives are hold in most agile methodologies on a regular basis. A retrospective is a meeting in which agile developers look back on past events and made mistakes. Future measures are discussed hereupon. Both creative and interdisciplinary teams can benefit from retrospectives. Especially interdisciplinary teams should use such meetings to refine their particular way of collaboration. Creative teams can use them to share ideas and zoom out to have a look at the big picture. The latter prevents people from becoming obsessed with details.

Related to: coaching (6.10) • reflect (6.12)

Quality work

Many agile methodologies list methods and tools that ensure a high standard of their products, e.g., automated builds, automated tests, continuous integration, refactoring, pair programming, or velocity. Most of them are very specific to software development and tend to be overkill in creative and interdisciplinary projects if software development has only a small part in these projects. Furthermore, quality work isn't the goal of creative projects. It's rather imperfect prototypes, experiments, and proof of concepts. Nevertheless, creative teams should adopt the principle of using (and creating) support tools that accelerate routine work and assist them in developing prototypes.

Related to: permanent prototyping (6.6) • build support tools (6.7)

Working software

Agile teams try to keep their products in a state in which it can always be delivered. This improves feedback because customers are able to respond quickly to recent changes. Creative teams, too, should try to maintain their prototypes in a working state. A working prototype helps creative teams to communicate ideas and to present these ideas to other people. It's also an important proof of concept, a learning platform, and a groundwork for further ideas.

Related to: permanent prototyping (6.6) • small next tasks (6.8)

Simplicity

In order to gain feedback as soon as possible, agile methodologies appreciate simple solutions that don't cover all possible eventualities. Simplicity can help creative teams to accelerate prototyping, but it may also limit ideation and the scope of thinking.

Related to: think different (6.4) • creativity techniques (6.5) • permanent prototyping (6.6)

Waste and impediments

Lean software development states that everything not adding value to the customer is considered to be waste. Then again, there is also truth in the idiom “one man’s waste is another man’s treasure”. Especially creative work benefits from “waste” because it provides stimuli: people have to think how waste can be (re)used and how to overcome its limitations. Extra time spent on incubation is another example of “waste”. The problem is that there’s no general rule that differentiates valuable waste from wasteful waste. In creative projects, for example, it’s often worth to sacrifice efficiency for inspirational input.

Organizational overhead and impediments like bureaucracy should be minimized. Agile, creative, and interdisciplinary teamwork should be based on direct collaboration instead of multiple organizational layers where middlemen and indirect communication are an inevitable part of the work process.

Related to: think different (6.4) • creativity techniques (6.5) • reflect (6.12)

Coaching

Coaches (e.g., Scrum Masters) play an important role in most agile methodologies. They eliminate impediments that hamper the work of agile teams in social, operational, and organizational manner. This is especially useful for interdisciplinary teams because coaches can act as mediator between different domains in case of disputes. Moreover, they can provide creative teams with links and stimuli. As defined in agile methodologies, coaches should play only a passive role and support self-organized teams, not lead them. People who are allowed to make decisions on their own tend to be more motivated. This also creates an atmosphere where creativity can flourish naturally (not artificially).

Related to: open atmosphere (6.2) • think different (6.4) • coaching (6.10) • forge links (6.11)

Supportive environments

Agile methodologies build supportive environments where developers are able to work without interruptions. Workbenches are usually provided to save agile developers from routine work and support them in software development (e.g., virtual machines with pre-installed IDEs and software tools). Creative teams should be supported as well, however, it’s difficult to define a creative workbench because of the huge range of possible tools and materials. Basic starter kits have been used in the preliminary studies (see chapter 2): new teams were equipped with a basic set of tools and materials whereas special and sophisticated items were presented but not distributed by default.

Related to: build support tools (6.7) • coaching (6.10)

7.2. Agile methodologies

The following section examines a choice of agile methodologies and their distinctive features with regard to the made adaptations. It'll be shown that agile methodologies vary considerably although they share the same principles which are discussed next.

Agile Manifesto

The Agile Manifesto (Beck et al., 2001) is the most general definition of agile software development. It consists of twelve principles. Unlike other agile methodologies, the agile manifesto doesn't define any concrete methods. The following table 7.1 lists each principle together with its respective adaptation.

Principles of the Agile Manifesto	Adaptations
Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.	The highest priority is to appreciate ideas, motivation, and passion of each project member properly by supporting diverse thinking, experiments, and play. There is usually no customer (in the beginning).
Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.	Change happens frequently due to playful experiments and prototyping. Goals are developed during the course of prototyping. Requirements are rather avoided.
Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.	Tasks are finished (or abandoned) in less than a week. Only a small, manageable number of tasks is processed in parallel.
Business people and developers must work together daily throughout the project.	Interdisciplinary teams are created based on common goals and interests. Collaboration between domains is strongly intertwined.
Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.	Ditto. In addition, various links and stimuli are provided. Open projects are preferred that invite everyone to participate.

The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.	Ditto. Collaboration over the internet is allowed to some degree. Results are made public by default.
Working software is the primary measure of progress.	The number of made experience and experiments are the primary measure of progress (including time for ideation and incubation).
Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.	Projects may change or fail. Everyone is allowed to create, join, or leave a project at any time. The emphasis is on constant experiments, play, and proof of concepts.
Continuous attention to technical excellence and good design enhances agility.	Only disposable prototypes are built. Proof of concept stands above quality. Long-lasting support tools are still maintained properly. Successful prototypes may be redeveloped in accordance with professional practices.
Simplicity – the art of maximizing the amount of work not done – is essential.	Creativity stands above simplicity - including incubation and “waste”. Coaches watch out for too ambitious, complex, or overloaded projects. Such projects are split into multiple projects.
The best architectures, requirements, and designs emerge from self-organizing teams.	The best creative results emerge from self-organized, independent, and interdisciplinary teams supported by coaches and the environment / organization.
At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.	Constant reflection is ensured by, e.g., coaches, guest talks, incubation time, meetings, and fixed time for documentation. Experienced coaches keep their eyes on running projects. They give also advise if necessary.

Table 7.1.: Adaptations compared to the principles of the Agile Manifesto

Lean software development

Lean software development (Poppendieck and Poppendieck, 2003, 2007) is based on seven principles being all about increasing business value. Lean software development doesn't give any specific instructions, it's rather a philosophy than a methodology and thus similar to the Agile Manifesto. All seven principles can be applied to creative and interdisciplinary projects without adaptations except of "build integrity in" and "eliminate waste". The following table 7.2 lists the principles as well as possible measurements to achieve them.

Lean principles	**Measurements**
Amplify learning	Permanent prototyping ensures learning by doing. In addition: Coaches may act as trainers. Exhibitions, lectures, and workshops are attended and organized on a regular basis. Interdisciplinary team members teach each other.
Build integrity in	Adaptation: The emphasis is on evolutionary and exploratory prototyping instead of quality assurance.
Decide as late as possible	Documentation is delayed until results are certain. Specifications are avoided. Planning is minimized. Qualified over quantified descriptions.
Deliver as fast as possible	Permanent prototyping is used to gain proof of concepts, experience, and feedback as soon as possible.
Eliminate waste	Adaptation: Waste should be used as an additional source of inspiration but only to a certain extent.
Empower the team	Coaches as well as the organization support self-organized teams in any respect, e.g., by providing aid, information, inspiration, training, links, mediation, and resources.
See the whole	Frequent reflection is promoted by coaches and the organization. This includes lean documentation, incubation time, and regular meetings.

Table 7.2.: Measurements in regard to the principles of lean software development

Kanban

Kanban (Anderson and Reinertsen, 2010) consists of six core practices that are mostly about process management. The primary goal of Kanban is to optimize the workflow. For this, Kanban favors a pull-system in which only a limited number of tasks is processed at the same time. Such a pull-system is also suggested for creative work in the previous chapter 6: A new task is processed as soon as a former task has been finished. The number of tasks processed in parallel is limited as well as each task's process time. This approach causes only little bureaucracy since long-term strategies aren't considered. Nonetheless, discussions are still needed in order to agree on the next imminent task(s). Especially creative projects can benefit from pull-systems because they live on short-term decisions based upon the moment what makes them very hard to schedule in the long term. The following table 7.3 summarizes the made adaptations in relation to Kanban's practices.

Kanban's practices	**Adaptations**
Visualise	A whiteboard visualizes the work-in-progress. The primary purpose is to facilitate collaboration, not to optimize the workflow.
Limit work-in-process	No adaptations made. A new task is processed as soon as a former task has been finished. Only a limited number of tasks is processed at the same time. Each task must be finished within a short time limit.
Manage flow	The workflow isn't monitored, measured, or reported. It's arguable if such analysis is worth the effort in creative work.
Make policies explicit	The project team decides what tasks are processed next. Each team finds its own way of decision-making.
Implement feedback loops	Prototyping and meetings are used to foster a constant circulation of experience and feedback. Coaches and lean documentation ensure that project members frequently reflect on their work.
Improve collaboratively, evolve experimentally	No adaptations. Each interdisciplinary team develops a common language and understanding over time by working on small, incremental, and evolutionary prototypes.

Table 7.3.: Adaptations compared to Kanban's core practices

Extreme Programming

Extreme Programming (Beck and Andres, 2004) defines practices, principles, and values that range from software programming to project management. In contrast to Extreme Programming, the methods suggested in chapter 6 are all optional. The reason for this discrepancy is that creative and interdisciplinary projects vary considerably which makes it impossible to define a comprehensive solution. All measures have to be adapted to the particular people and situation instead.

The five values of Extreme Programming (communication, courage, feedback, simplicity, and respect) are similar to the values suggested in section 6.2. Please note that the value "simplicity" isn't necessary beneficial for creative work because it might also restrict ideas. Diversity, for example, can increase complexity as well as creativity.

A detailed discussion on the applicability of Extreme Programming can be found in the bachelor thesis by Müller (2010). In summary, she concludes that software engineering practices (e.g., pair programming, test-driven design) aren't suitable for creative and interdisciplinary projects. Nonetheless, some of them can still be adapted: for example, instead of pair programming, pairing can be used for design and implementation processes (Jackson, 2013). Methods relating management issues like user stories can be adapted too as described earlier in section 7.1.

Scrum

Scrum (Schwaber, 2004) is about project and process management. It doesn't prescribe software programming practices like Extreme Programming. Scrum is structured in sprint plannings, sprints, sprint reviews, and sprint retrospectives. All these activities form a single iteration cycle being constantly and frequently repeated. Creative projects should rather be scheduled on a temporary basis because goals change so fast, due to trial & error, that most of them become obsolete very quickly.

Besides iterative planning, Scrum advocates the idea of coaching. Coaches, also called Scrum Master in this case, provide care for the agile team and eliminate impediments. They don't lead but they still represent the agile team to external sponsors. Coaching as described in section 6.10 is more versatile in contrast - depending on the actual role, a coach inspires team members, provides stimuli, gives advice, takes care of organizational affairs, mediates disputes, or forges links between people. One or more coaches may be assigned to one team. The same coach may also be assigned to different teams. The following table 7.4 compares Scrum to the made adaptations.

Scrum	Adaptations
Teams of 5-9 software developers.	Small interdisciplinary teams (less than 7 members). Teams are dynamically built by common interests and goals.
Teams consist of interchangeable generalists.	Teams may also consist of unique experts who aren't interchangeable.
Team is cross functional.	Team is interdisciplinary (including engineers and non-engineers).
Team defines the process.	Ditto.
A Scrum Master takes care of the whole team.	One or more coaches take care of the team. Each coach may fulfill a different role.
Systematic process: sprint planning, sprint, sprint review, and sprint retrospective	Dynamic process: no fixed order.
Work is done in short bursts: less than 30 days each sprint (iteration).	Each task is limited to a week at the utmost.
Product Owner (customer) provides the ideas, specifications, and work requests.	The team develops its goals.
Product Owner determines priority of the work requests.	The team determines the priority of the next task(s).
Product Owner provides validation for each work request frequently (sprint review).	No formal validation is used. The team chooses its own quality goals. However, only disposable prototypes are allowed. This limits its quality to some extent.
User stories are written to document the customers' work requests.	Ideas come from the team members; they are documented in a shared story book.
Work requests are scheduled and implemented in sprints (iterations). Each sprint has a fixed time frame.	Only the next imminent tasks (limited number) are scheduled. Instead of static iterations, a dynamic pull-system is favored.

Sprint planning is held to prioritize the work that has to be done in the next sprint.	The team looks for a new task as soon as a former task has been completed.
A whiteboard is used to allocate current tasks among the developers within the sprint.	Ditto. But the whiteboard doesn't contain future tasks, only tasks in progress.
Daily stand-up meetings detect any adjustments needed.	Ditto.
Work starts and stops with planning and review.	There are no fixed activities. Meetings and scheduling is done frequently but dynamically on demand. However, documentation should have a fixed time frame at the end of the day.
Meetings are separated by purpose (feedback, planning, reflection, or status report).	There are no special purpose meetings defined, but they aren't prohibited either.
Burndown charts are used to track the work progress in each sprint.	A whiteboard keeps track of the current tasks. No charts are prescribed. No monitoring of progress. Fishbone charts are suggested.
Product backlog and sprint backlog document the progress.	Documentation (and planning) is done in a shared, informal story book.
Sprint retrospective for process improvements.	Reflection happens by frequent meetings and fixed time frames for documentation. Coaches give further aid.
Always potential shippable code.	Prototypes are always disposable. If possible, they are always presentable.

Table 7.4.: Adaptations compared to Scrum

7.3. Compatibility of agile, creative, and interdisciplinary work

The following figure 7.1 illustrates the distinctive features of agile, creative, and interdisciplinary projects as well as their points of intersection:

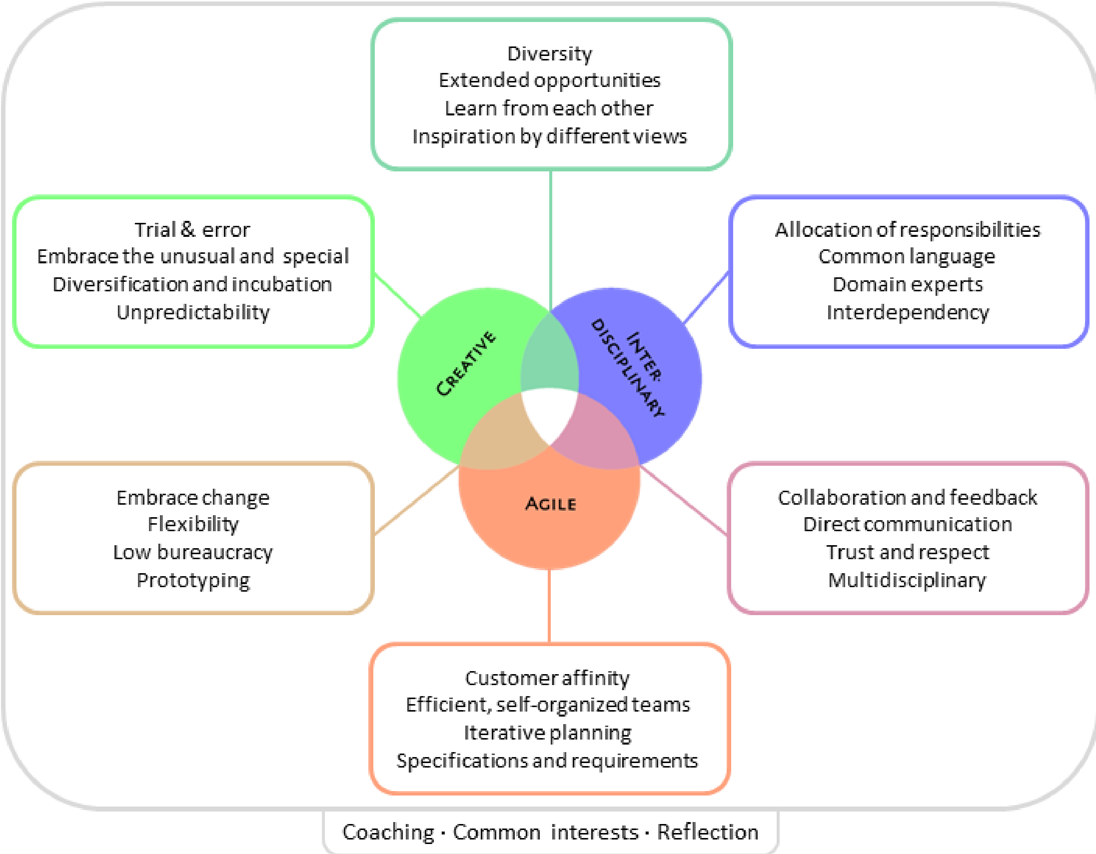


Figure 7.1.: Intersections of agile, creative, and interdisciplinary projects

Creative projects are characterized by unpredictability. Unusual ideas are favored and can change constantly. Agile methodologies are able to handle unpredictability too but not to the same degree as creative work. In creative projects, ideas and tasks come from the people who actually implement them whereas agile teams work on tasks requested by their customers. Teamwork isn't really a key feature of creative work, but it isn't unusual either. Both agile and creative projects use prototyping for implementation. Implementation is based on specifications and requirements in agile projects whereas creative work is often distinguished by gut decision and sense. Efficient work in agile projects stands in stark contrast to incubation time. Finally, both agile and creative project share low bureaucracy and flexible projects.

Interdisciplinary projects are all about interdependent teamwork of different domain experts. This calls for the need of a common language. Agile teams learn the domain language of their customers too but not vice versa. Frequent feedback is an excellent method to avoid misunderstandings between different domain experts. Collaboration, direct communication, and trust & respect build a common ground in both agile and interdisciplinary projects. Agile projects seem to be a special case of interdisciplinary work because agile teams collaborate with different domains too. However, they still remain independent in terms of implementation. The Achilles' heel of interdisciplinary work is an unbalanced allocation of responsibilities (including decisions, resources, and ownership). Agile teams uniformly consist of software developers, who usually share the same goals, whereas interdisciplinary teams have to bring the interests of different domains under one roof.

Both creative and interdisciplinary work can inspire each other, open new opportunities, and thus enlarge the diversity of ideas. The main problem is to maintain motivation and to reduce conflicts because not all ideas are equally shared among all the involved domains and not all ideas can be implemented. In the worst case, each domain follows a different vision without knowing or understanding the vision of the other domains.

Agile methodologies are designed to separate responsibilities between customers (requirements) and developers (implementation). Such a clear separation is very difficult to achieve in interdisciplinary teams. In face of several opposing interests, it's nearly impossible to equally achieve freedom and intrinsic motivation among all interdisciplinary project members. This may cause further problems like competition for resources as well as blame games in case of project failures. That's why common interests and reflection are crucial factors for any kind of teamwork. Otherwise, a project is likely to fail. Unfortunately, it's very difficult to create interdisciplinary teams with common goals and interests on purpose as discussed in chapter 4.

Agile, creative, and interdisciplinary projects are likewise compatible with coaching, common interests, and reflection. Passive coaches are excellent to provide support in general. Common interests usually alleviate the negative effects of conflicts. Reflection is the basis for collaboration and refinements. On the whole, all three project types have a common ground and they complement each other for the most part:

- Creativity contributes constant stimuli and prevents routine
- Interdisciplinarity contributes new dimensions of thinking and opportunities
- Agile methodologies contribute techniques for iterative and flexible project management

Nonetheless, some contradictions do exist and should be addressed in the first place - see also section 6.1 “settle the prerequisites” in this regard:

- allocation of responsibilities (including decisions, resources, and ownership)
- freedom and independence in regard to stakeholders and specifications
- loss of control (caused by failures and unpredictable results)
- trade-off between creativity & productivity and design & implementation
- opposing interests and goals within the team

7.4. Conclusion

This chapter has shown that agile methodologies need to be adapted in order to support creative work in interdisciplinary projects. Especially customer affinity doesn’t work well with creative projects. Creative teams should be independent and they should develop their own ideas instead. Nonetheless, agile methodologies are still suitable for creative and interdisciplinary work due to their iterative character based on frequent feedback and prototyping. Creative work is characterized by unpredictability. This is compatible with agile methodologies to some degree because change is a common factor in agile and creative projects. However, while failures are accepted in creative work, they are avoided in agile methodologies. Agile methodologies try to be more predictable and thus make use of specifications and requirements which generally restrict creative work. Creativity needs incubation time, randomness, and diversity. However, these measures come at the expense of productivity. This might also be the reason why creativity isn’t much a topic in the agile world. Maybe it’s worth to rethink agile methodologies in terms of creativity.

The methods suggested in the previous chapter 6 are an attempt to unite the best of agile, creative, and interdisciplinary work. The main ingredients are:

- diversity by creativity techniques and interdisciplinary teams
- extended thinking and opportunities by interdisciplinary teams
- trial & error by experiments and prototyping (including failures)
- flexibility by short-term, iterative planning
- frequent feedback by coaching, meetings, and lean documentation
- little bureaucracy by informal processes, structures, and lean documentation

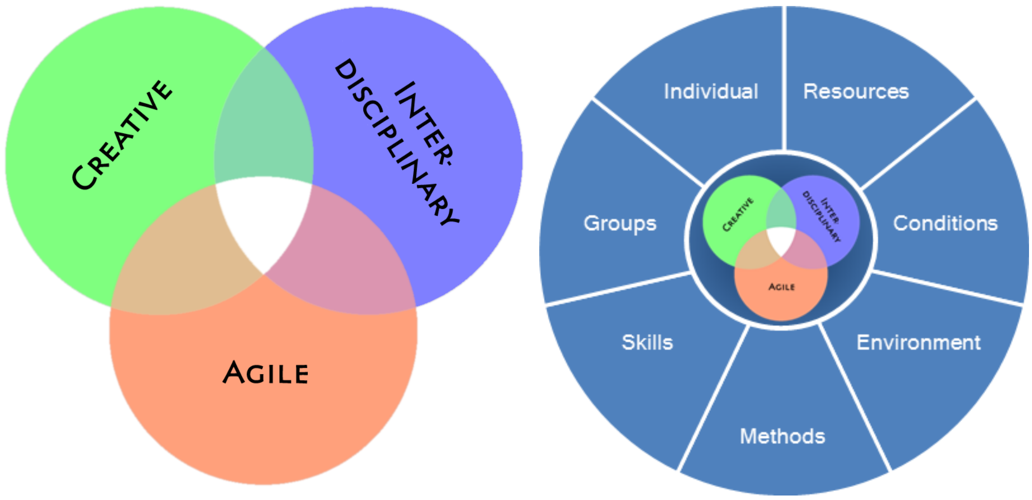
The characteristics of agile methodologies are thereby amplified: higher adaptability, fewer predictability. This is mainly caused by allowing failures, a larger scope of change, and teams that are more independent of stakeholders. The starting point of each project should rather be an idea than a certain (given) problem.

8. Final thoughts

The final chapter starts with a synopsis of findings from this thesis. It's followed by a discussion why creativity should be supported at all. Further topics, that would go beyond the scope of this thesis, are briefly outlined including possible future prospects.

8.1. Résumé

This thesis has shown that agile methods can be adapted to support creativity in interdisciplinary projects. Agile, creative, and interdisciplinary work complement each other for the most part, but many aspects on different levels have to be considered. It has been shown that



(a) Agile, creative, and interdisciplinary work complement one another

(b) Many aspects influence project work

all aspects influence each other. Each aspect can both foster and restrict creativity, especially if it's applied in an extreme way. Because of this, a silver bullet doesn't exist. Constant adaptation and reflection is needed. Instead of clinging to a particular method or methodology, a set of methods should be at one's disposal. Each method is then only applied if appropriate - like using the right tool from a toolbox. All in all, it isn't just about finding the right set of methods, it's about finding and providing the right combination of conditions, environment, groups, individuals, skills, methods, and resources on an ongoing basis.

Certainly, it's hard to adapt to the particular situation on an ongoing basis. Each measure has to be looked up, chosen, applied, and evaluated. Trial & error is consequently an inevitable activity in order to learn new measures and to become able to choose in the first place. Much time and effort has to be spent for this. For example, the Rational Unified Process is a very large collection of practices and gives so much choice that it's challenging to use (Fowler, 2005; IBM, 2013). Scrum or Extreme Programming, on the other hand, are ready-to-use methodologies which can be applied without further ado. But not every team or organization is able to apply Scrum, neither is Scrum an all-purpose methodology. It still provides a good starting point for adaptations though. That's also why agile methodologies have been used in this thesis: as a starting point for creative and interdisciplinary projects. Adaptations have been made to improve collaboration, diversity, diversification, flexibility, and individual motivation. It's an attempt to amplify the best of agile, creative, and interdisciplinary work:

- Agile methodologies provide the basis for team-oriented, flexible, iterative prototyping
- Creativity provides techniques for a constant flow of new ideas and stimuli
- Interdisciplinarity adds new dimensions (of thinking and opportunities)

As mentioned, there is no silver bullet, however, eliminating impediments seems to be a viable approach in general (e.g., disputes, dominance issues, or strict requirements). Regarding to this, a passive approach is favored in which self-organized teams are supported and not controlled by the circumstances. This requires teams that are able to work independently and come to an agreement in time. Coaching and common interests are considered to be essential ingredients for this purpose.

Finally, it's important to discuss how creativity is valued. Creativity cannot grow if it's constantly undermined by organizational objectives like short deadlines or productivity. Each organization has to support creativity in every aspect at any time - not in a fixed, limited manner. In the end, creativity shouldn't be considered as an end in itself, it's a part of us that makes life and work interesting and enjoyable.

The more I love my idea, the less money it makes. (Anonymous)

8.2. Why support creativity?

This section gives some thoughts to the reasons why creativity should be supported.

Find your element

But, if you have nothing at all to create, then perhaps you create yourself. (Carl Gustav Jung)

In the context of university (and beyond), creativity can aid people in finding their element, talent, or passion. This can be achieved by giving them the freedom to try something new. An open mind that contains many perspectives is more likely to find its element. People who work in their element are believed to be more happy, motivated, and creative. In a way, creativity is also about the purpose of life:

Why do I do what I do?
Because I can do?
Because I have to do?
Because I love to do?

This implies the question what people should experience and learn in life or school? What they learn early on definitely affects what they'll do later on. But this isn't necessarily what they really want to do. Creativity gives people the chance to learn what they could be beyond what they already know. Creativity can help to find what someone really wants to do. That's also why most methods suggested in chapter 6 respect the particular individual within the team by supporting learning, personal experience, participation, and intrinsic motivation. Self-organized work and experiments based on trial & error are the favored ingredients in this regard.

Find innovation

The stone age didn't end because they ran out of stones. (Unknown)

Creativity is said to stimulate innovation. First of all, it depends on the individual whether something is considered innovative or not. For example, one might consider a new product innovative whereas someone else might already know something similar and hence won't refer to it as innovative. This might also be a reason why there is no guarantee for innovation. Nevertheless, innovation still happens. But how?

- by creating new problems instead of solving existing problems
- by approaching problems from different views and unusual perspectives
- by approaching problems with different methods and unusual tools

Creativity is often requested to improve innovation. Creativity can support the three stated measures and hence increase the chances of innovation, but it increases unpredictability as well. Because of this, creativity usually doesn't increase to the same extent as innovation. And the more attention is paid to creativity, the less likely it is to be creative (Dörre and Neis, 2010). Instead of forcing innovation systematically, it seems to be better to create a passive system that simply provides creative people with the capabilities, freedom, and resources they need. In this connection, creativity appears to be an expensive and somewhat risky luxury that gives no guarantee for innovation. Nonetheless, innovation requires open problem spaces where problems aren't assigned but created and shaped by creative people who are allowed to come up with divergent approaches.

> *We are like dwarfs sitting on the shoulders of giants. We see more, and things that are more distant, than they did, not because our sight is superior or because we are taller than they, but because they raise us up, and by their great stature add to ours. (John of Salisbury)*

Innovation is also based on the existing work of others. Using the understanding gained by major thinkers, who have gone before, makes it both easier and harder to create innovation. It also means that innovation is an inevitable process that happens and grows over time. However, clinging to existing solutions and paradigms can be problematic in regard to innovation. Creativity provides new ways of thinking to find new problems that don't fit into existing patterns, methodologies, or paradigms. Such new problems can lead to a paradigm shift which enables one to solve it properly. However, the created paradigm may hold further problems which again may call for new paradigms (Kuhn and Krüger, 1978). All in all, innovation seems to be a cycle of constant downfall and refinement. This would imply that innovation needs constant reinvention in every aspect. Creativity can be a viable tool for this but it has to be used with care detached from false expectations.

Referring to this, how can creativity be used to create innovation in computer science? First, agile methodologies aren't designed to create innovation. They're designed to solve existing business problems of customers. They aren't designed to create new problems. Many innovative results arise from hobbies or independent projects developed by passionate programmers who don't necessarily follow a particular vision or serve a target group. And yet, there is no methodology for innovative software development. However, agile methodologies and the methods suggested in this thesis appear to be a good starting point to develop such a methodology. It should be based on the following four principles:

1. Teams are independent, interdisciplinary, passively supported, and self-organized
2. Varying measures are applied dynamically (toolbox-oriented approach)
3. Diversity, diversification, and trial & error are an inherent part of the whole process
4. Focus on creating new problems instead of solving existing problems (of other people)

Find new methodologies and problems

Problems cannot be solved by the same level of thinking that created them. (Albert Einstein)

The methods suggested in this thesis are probably a reflection of the methods that are much in demand at this particular time. If this thesis would be written 10 years in the future, it would very likely be based on other methodologies and also suggest other methods that are present (or popular) then. Agile methodologies have been chosen in this thesis because they are well-known to the author and because they appeared suitable. However, agile is not the final answer to creativity. It's very likely that people from other domains would suggest very different methods that are suitable as well.

People are biased by the methodologies they know. Popular methodologies attract even more people. Being fixated on a particular methodology causes presumably a smaller perspective and perception. A methodology is designed to solve a particular problem (or problem space). If people commit themselves to a certain methodology, they tend to see all problems in a way that fits exactly into their methodology because it's what they know and it seems the most effective approach to them. This again leads to default solution patterns which are not really adapted to the problem itself. Creativity may be a way to engage people to change their habits and widen their thinking so that they start to approach problems from different directions. The clash of multiple methodologies in interdisciplinary projects, for example, may result in new, combined methodologies as well.

Besides being influenced by well-known methodologies, some methodologies are also suggested just because they do something which has been neglected so far. Such methodologies may become very popular and the next trend. Methodologies that are popular may be overemphasized until people realize that not all problems are properly solved by them. These people may then come up with new methodologies which solve particular problems in a better way. The rise of new problems may cause new methodologies too. However, this seems only true for problems that are too hurtful to solve with the existing methodology - as already mentioned, people tend to adjust all problems to their methodology, so that they don't have to change their familiar behavior. Some methodologies are also neglected just because they seem too expensive compared to the benefits (including, e.g., onsite customers, pair-programming, proper retrospectives, or incubation time).

New methodologies are needed to solve existing problems more adequate. Some methodologies aren't even able to solve a given problem at all. So, new problems are able to create new methodologies. As illustrated in the following figure 8.1, problems and methodologies depend on each other. A change of methodology usually requires a change of problem and vice versa - this requirement still exists even if people maintain the status quo and don't adapt to the new situation. Change is needed to create something more adequate. Creativity may be a catalyst for constant change urging people to adapt and thus create new methodologies and new problems.

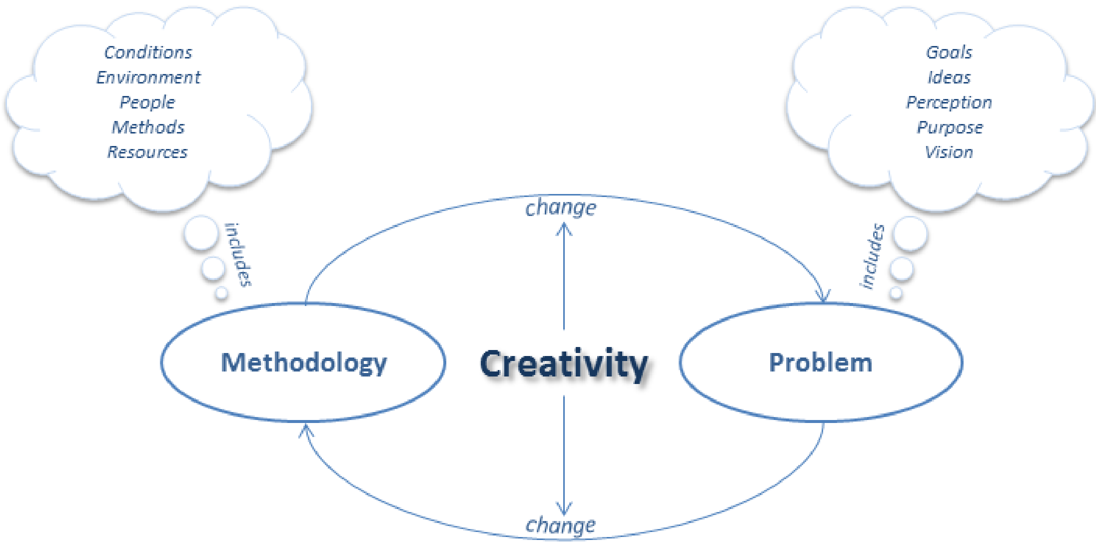


Figure 8.1.: Creativity appears to be a catalyst for constant change which potentially creates new problems and methodologies

8.3. What else needs to be done?

This section is about topics that have only been broached in this thesis and should be discussed in more detail.

Further research on patterns

Further research in terms of patterns is required on all aspects that have been addressed in this thesis. Each special pattern should be examined on its particular purpose as well as its assets and drawbacks. This includes the following points:

- Conditions that are suitable (or not) for a particular method and vice versa
- Patterns in social aspects (see chapter 5)
- Further elaboration of social aspects including psychological group behavior
- Patterns for environmental, personal, social, and methodical aspects (as a methodology)
- Suggestions for alternative conditions, methods, and social aspects (based on similarity)

Additional courses are needed in order to collect the empirical data for these analyses.

Suitability of agile tools

Many products exist that support agile methodologies. These products cover, for example, analytics, collaboration, continuous delivery, iteration planning, project management, testing, ticketing, or tracking[1]. It would be interesting to evaluate these products to determine whether or not they are adequate for creative and interdisciplinary work, and furthermore, what adaptations are necessary and possible.

Creativity toolkits and workbenches

It's remarkable how new technologies have empowered people to be creative in the last few decades, be it

- software tools (e.g., Adobe Muse, Blockly, Processing, Scratch)
- modding support (e.g., creative common licenses, plugins, open hardware, open source)
- tinker hardware (e.g., 3D printers, Arduino, Lego Mindstorms)
- sharing platforms (e.g., Flickr, Scratch, Sourceforge, Youtube)
- distribution platforms (e.g., App Store, iTunes, Lulu, Steam, Youtube)
- funding platforms (e.g., Indiegogo, Kickstarter)
- fabrication services (e.g., printing, crowdsourcing, PCB boards)

However, there's still room for improvement - further toolkits for user innovation are needed as well as further refinements (Von Hippel, 2005). Especially software development tools like Arduino have to be easy to use in order to make sophisticated results possible even for non-professional programmers. This extends to the design of workbenches for creative work: What combination of environment, materials, methods, and tools is needed to support beginners and creative people?

> *I think it's fair to say that personal computers have become the most empowering tool we've ever created. They're tools of communication, they're tools of creativity, and they can be shaped by their user. (Bill Gates)*

Creativity training

Although many tools already exist, creative people are still needed who use them to create content. Providing tools is just the first step. It's a call for proper creativity training including parents, kindergarten, school, university, and society; all of them should induce and prepare young people to create content instead of just consuming it. This includes the elaboration of courses and course materials for parents, teachers, and students.

[1] See exemplary products on http://www.atlassian.com or http://www.thoughtworks.com/products

Personalized training

It's questionable if students will still learn in fixed classes as they do today. Personalized learning may become a key development of the next century. Online education will be able to adapt its training program dynamically to the skills and knowledge of the individual student. Moreover, training can be made free and accessible for everyone regardless of the student's social status and origin. Individualized training can help to identify and foster the individual creativity and talents of each student.

> *I said schools as we know them now, they're obsolete. I'm not saying they're broken. It's quite fashionable to say that the education system's broken. It's not broken. It's wonderfully constructed. It's just that we don't need it anymore. It's outdated. (Mitra, 2013)*

The point of Mitra is that the today's school system is formally designed for people of the 18th century. Therefore, it teaches things that have been made obsolete by technology. It's a justified complaint, however, it may be a mistake to abandon the standardized school system entirely. By teaching people a broad basis of knowledge, they have more chances to be creative - the decisive factor is diversity. Besides teaching common knowledge, schools should also offer room for own experiments including failures and uncertain results.

Cultivating creativity

Creativity should be an inherent part of everyday life, school, and work. This means more time and practice for creativity techniques, diversification, play, incubation, and reflection. Such creativity training would also cover awareness, emotions, emotional intelligence, empathy, and instincts instead of focusing solely on expertise. For example, most people learn or teach popular matter that guarantees a job and money. This undermines people and talents that are less useful in terms of economy, however, exactly these people and talents are needed for more creativity, diversity, and perspectives (e.g., athletes, artists, dancers, and designers). The top priorities of today's society seem to be efficiency, productivity, and profit which leave little room for any sort of creativity other than that supported by the mainstream.

Most people take art, creativity, or culture for granted, but they seem not be able to appreciate them. If creativity training would be common, it could increase the appreciation of creative work in general causing new, diverse jobs as well. This would lead to a society that scoops its wealth on a wider range of opportunities.

> *The Creative Class is the core force of economic growth in our future economy. Economic growth is driven by creativity: Technological creativity (new products and technologies), economic creativity (entrepreneurship, new businesses and industries), cultural and artistic creativity (invent new ways of thinking). Those three things have to come together to spur economic growth. (Florida, 2012)*

Experts and engineers are still required, but just being specialized shouldn't be enough anymore. Instead of having a singular perception of ability, experts need to enlarge their spectrum of thinking. This requires courage for new and different views so that new ideas are proposed or considered in the first place. For this, organizations have to appreciate and support individual creativity properly.

To think outside of the box you must be outside of the box. (Doyle, 2011)

Decelerated society

A major problem of creativity is the fact that it costs precious time. Today, people seem to be primarily busy with rushing from A to B, consuming C, and rushing back to A (or to the next appointment D). In doing so, people get stressed and unaware. Such people won't be creative, they will presumably consume to relax instead. It's not yet foreseeable whether new technologies, like fully automated personal organizers, will provide people with more time or just arrange life more efficient. Even children get prepared for working life at an increasingly early age these days. One cannot expect creativity from people who are treated like machines that are constantly tuned to be more efficient.

Creative software development

Whatever software development approach is used today, the larger part of developers play only a passive role in it; they typically implement the requirements of other people. Moreover, requirements are rarely raised to question if a customer requests them. Developers should get more involved and not just complete the checklist. Developers should reflect the given requirements and come up with new suggestions.

Indie developers of (mobile) apps and games have shown in the last few years how much creative potential actually exists if no requirements have to be fulfilled - because of the lack of stakeholders. However, such independent development requires still courage due to uncertain funding. Supporting entrepreneurs and independent developers via crowdfunding (and state assistance) has a huge potential to foster independent, creative work in the future. In this regard, it's worth to rethink classical research & development departments and think tanks: they should be open for the public instead of having exclusive clusters for a designated elite. The Barefoot College[2] and Hole-in-the-Wall[3] are projects that demonstrate what potential exist even in uneducated people if given the necessary freedom and opportunity.

[2] See http://www.barefootcollege.org

[3] See http://www.hole-in-the-wall.com

8.4. Future prospects

This section gives some thoughts to prospects regarding creativity and computer technologies.

The creative public

Open innovation is an approach that makes research and production of companies available to a broad public (Chesbrough, 2006; Chesbrough et al., 2008). Furthermore, internet technologies allow companies, governments, universities, or research facilities to access a large pool of creative people all over the world and involve them in the product development. For example, DARPA involves the public into the design and manufacturing process of their next autonomous vehicles[4]. Open innovation is about being open for external ideas and designs. More diverse ideas could be realized if companies let the public become co-creators and the backbone of their business models by granting access to their resources Merchant (2012). Moreover, the development and production of goods could be made democratic and individualized - permanent beta and crowdfunding are the first steps on this road. Florida (2012) states that the creative class is pin-pointed in certain cities, but the creative class can also be accessed from everywhere in the world today. Creative common licenses and open data/hardware/software could support the creative public even more.

Nonetheless, this openness requires still methods to collaborate with the creative public. The methods suggested in this thesis may act as a first foundation for this kind of development.

From tool to partner

Can a computer become a domain of its own in interdisciplinary work? Computers already support people with various tasks such as automation, pattern recognition, mixing, and randomization. But computers may become more than just support tools. Maybe one day, computers will have some kind of conscience mind that enable them to really understand what they're doing and why they're doing it. Please note that computer programs already exist that are able to act in a creative way[5]. However, these tools are based on rules and randomness, not on perception and intention. It's about computers that become an additional domain on its own that independently interact with other domains in partnership. Such computers won't support people by just being tools, they will rather understand the particular situation in order to come up with own suggestions and are able to discuss them.

[4] See http://vehicleforge.org/about

[5] For example, artificial painter http://www.kurzweilcyberart.com, composer http://artsites.ucsc.edu/faculty/cope/, or news writer http://narrativescience.com

8.5. Is it worth the trouble?

As discussed in section 7.3, many additional issues have to be addressed if information science is combined with creative and interdisciplinary work. The possible benefits depend on the size of the tolerated solution space which has to be large enough; or else, the disadvantages would outweigh the advantages. Assuming that there is a sufficient solution space, creative and interdisciplinary work are then able to draw on all potential solutions that wouldn't be feasible otherwise. For example, without interdisciplinary research, there wouldn't be the transistor - and without transistors, there wouldn't be any PCs or smartphones today.

> *We are not students of some subject matter, but students of problems. And problems may cut right across the borders of any subject matter or discipline. (Popper, 2002)*

Solutions shouldn't come from science and economy only. For example, engineers usually come up with solutions that are perfect from a technical point of view, however, they might still be insufficient if they ignore the place of installation or the needs of the people. Such issues may range from simple things like the availability of spare parts, surrounding conditions, regular maintenance, or upkeep costs to unintentional impacts in cultural, ethical, social, or environmental manner. Creative and interdisciplinary teams are more likely to refer to these issues in advance. They're more capable of identifying the real problem in the first place and even assess whether a solution is necessary at all. A comprehensive solution should represent the society as a whole and should be a trade-off between all relevant aspects (e.g., environmental-, technical-, and social-wise). This requires involvement of people across science, economy, and society. Such transdisciplinarity approach is also more likely to find new problems that wouldn't be detected or examined else.

Creativity and interdisciplinarity enrich projects with new dimensions of thinking and opportunities which may lead to unforeseen solutions. However, there is no guarantee for this. On the contrary, such projects aren't unlikely to fail. Certainly, each failure is an opportunity to learn and to change for the better, but is it worth the price of high risks and unpredictability? If it's for the benefit of all relevant people, it should be paid. If it's for the benefit of a majority, it depends. If it's for the benefit of a minority, it's questionable.

Done.

Nothing is done. Everything in the world remains to be done or done over. The greatest picture is not yet painted, the greatest play isn't written, the greatest poem is unsung. There isn't in all the world a perfect railroad, nor a good government, nor a sound law. Physics, mathematics, and especially the most advanced and exact of the sciences are being fundamentally revised... Psychology, economics, and sociology are awaiting a Darwin, whose work in turn is awaiting an Einstein. (Lincoln Steffens)

Appendices

A. Components, materials, and tools

Most of the following resources were part of the preliminary studies described in chapter 2. Some of them are also inspired by the FabLab from MIT[1]. Because of the technological progress, such a list will never be complete. The sticking point is to provide a large variety of materials and tools that offer enough room for experiments and rapid prototyping. Software and hardware should be open source to allow extensions and sharing among participants. All tools and materials should also be free to use. Moreover, training should be offered to enable anyone to use the provided machines and tools.

> *Adding more resources above a "threshold of sufficiency" does not boost creativity. Below the threshold, however, a restriction of resources can dampen creativity. (Amabile, 1998)*

Handicraft materials: blocks, board games, boxes, cards, crayons, cutters, fabrics, foam glue, legos, needles, paper, paperboard, playmobil, ropes, rubber, saw, scissors, styrofoam, sugru, tubes, timber

Electronic components: assembly boards, batteries, cables, capacitors, connector plugs, fuses, power supply units, measurement equipment, nippers, rechargers, relays, resistors, transistors, wire cutters

Embedded computing:
Microcontrollers: Arduino, Gageteer, Gnublin DIP, Lego Mindstorms, smartphones, Raspberry Pi, TinkerForge.
Actuators: chromothermal materials, display, electroluminescence materials, fluids, lasers, LEDs, lights and light diffusion materials, heat wire, joysticks, magnets, motors, nitinol wire, OLEDs, projectors, speakers, servos, touch displays, touch panels, vibration motors.
Sensors: biometrics sensors (heartbeat, pulse, sweat), capacitive sensors, cameras, color sensors, gas sensors, gyroscopes, humidity sensors, kinect, photo sensors, infrared sensors, magnetometers, network adapters, motion sensor, radio transceivers and transmitters, RFIDs, ultrasonic sound sensors, temperature sensors.[2]

Mechanics: gears, hammers, hinges, joints, metals, motors, nails, pumps, screws, screw drivers, screw nuts, valves, wheels

[1] A more detailed and updated list can be found on http://fab.cba.mit.edu/about/fab

[2] See also http://www.digikey.com, http://www.sparkfun.com, or http://www.watterott.com

Workbench: 2D/3D printers, 2D/3D scanners, cutters, compressors, drilling machines, grinding machines, lasers, molder/caster, sewing machines, soldering stations, workstations

Simulation: CAD tools (e.g., Sketch-Up, Maya), CAE tools (e.g., Adams/Machinery), specialized IDEs (e.g., Processing), finite element analysis (e.g., Z88Aurora), game toolkits (e.g., UDK, Unity), schematics tools (e.g., Eagle)

For non-programmers: Adobe Muse, Arduino, Blockly, Hummingbird, Kodu Game Lab, Scratch, TinkerKit!

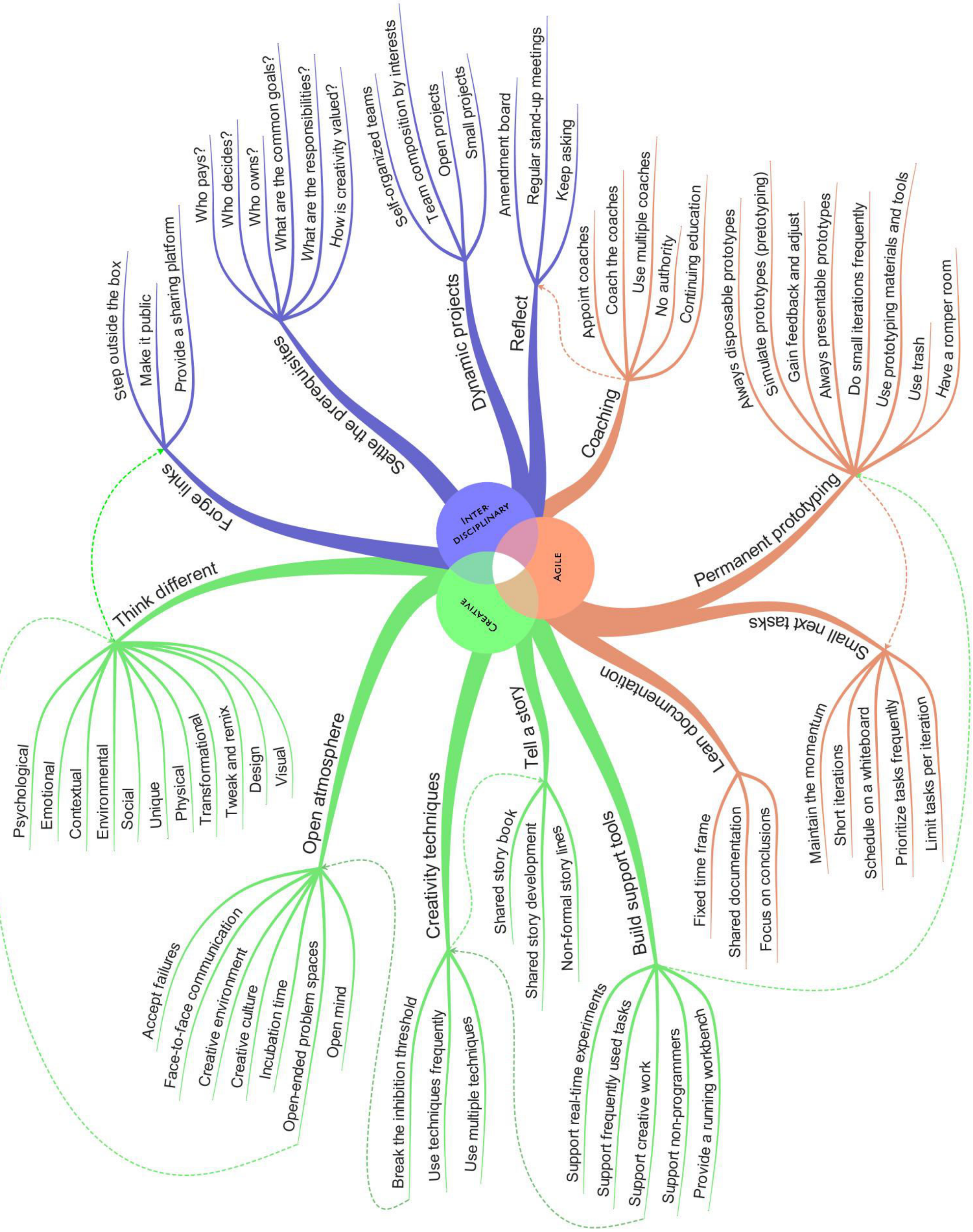
Please note that non-programmers are still poorly supported in terms of sophisticated tasks like parallelism, network communication, or feedback control systems. Valve's Filmmaker or most game engine editors (such as CryEngine, UDK Kismet, or Unity) combine intuitive user interfaces with powerful tools.

Documentation: blueprints, blogs, film camera, film edition software, image editing software, photo studio, photo camera, shared storage platform, tripods, websites

Lectures: blogs and wikis (for maintaining projects, specifications, and references), briefings and workshops for machines and tools , image/film material of past projects and works, in-a-nutshell handouts, online platform for exercises, posters, presentation materials, sharing, teaching materials for course instructors,

Reuse: Facilitate the reuse of materials by cooperating with organizations like MFTA[3] or Hanseatische Materialverwaltung[4].

[3] See http://mfta.org
[4] See http://hanseatische-materialverwaltung.de



Suggested methods and their respective origins in landscape format (see also chapter 6)

B. Creativity traits

Author	Skills and traits
Cropley (1982)	able to access high social status, enjoy social contacts, femininity, flexibility, independent, positive self-concept, psychologically thinking or feeling, responsibility, sensitivity, tolerance
Csíkszentmihályi (1997) (antithetical pairs)	humility/pride, imagination/sense of reality, introversion/extraversion, naive/prudent, passion/objectivity, physical strength and energy/calm and relaxed, rebellious and stormy/traditional and conservative, sense of responsibility/freedom, suffering and pain/pleasure
John et al. (2008) (Big Five Model of Personality)	appreciation for adventure, art, curiosity, emotion, imagination, unusual ideas, variety of experience (all traits are located in "Openness to experience")
Landau (1999)	curious, defend oneself against oppression and restriction, develop ideas carefully, experience in a sophisticated and comprehensive manner, fantasy, flexible, independent in judgment, less prone to bias, more confident, more dominant, more narcissistic, open, original, playful, prefer complexity, sensitive, versatile
Urban (2004)	ambiguity tolerance, curiosity, divergent thinking and acting, focus and effort, general knowledge and thinking skills, intrinsic motivation, openness, specific knowledge base and specific skills
Vester (2009) based on Guilford (1967)	analysis and synthesis of thought, association ability, conflict tolerance, divergent thinking, elaboration, flexibility, humor, imagination, originality, sensitivity, word fluency

Table B.1.: Skills and traits of creative individuals. See also section 4.1 on page 25

Please note that the traits by Csíkszentmihályi stand out because he favors antithetical creativity traits that enable people to switch from one trait to the other in dependence of the particular situation. This assumption implies that neither good nor bad creativity traits exist.

Agile methodology	**Skills and traits**
Agile Manifesto (Beck et al., 2001)	collaborative, communicative, customer-oriented, embrace change, focus, motivation, simplicity, reflective, self-organized, value individuals over process and tools, team-oriented
Crystal Clear (Cockburn, 2004)	collaborative, communicative, courage, feedback, focused, habitability, individualism, less formal, safety, self-improvement, trust, reflective, relaxed, respectful
Extreme Programming (Beck and Andres, 2004)	able to give and receive feedback, autodidactic, brave, collaborative, communicative, customer-oriented, embrace change, equal, expertise, humility, integrity, prefer simplicity, respectful
Scrum (Schwaber, 2004)	able to give and receive feedback, autodidactic, cooperative, equal, general knowledge and skills (to compensate drop outs of other project members), independent, responsible, self-organized, share common goal, team-oriented
Kanban (Anderson and Reinertsen, 2010)	team-oriented, self-organized

Table B.2.: Requested skills and traits of agile software developers. See also section 4.1 on page 26

Please note that Crystal Clear stands out since it prefers personal comfort to efficiency.

The following traits and skills are observations collected from the preliminary studies (see section 2) and from further literature: Amabile (1998, 1996b); Amabile and Kurtzberg (2001); Amabile (1996a); Amabile et al. (2004, 2002); Cropley (1982); Csíkszentmihályi (1997); Florida (2012); Frodeman et al. (2010); Goleman et al. (1992); Guilford (1967); Kurtzberg (2005); Landau (1999); Lassig (2009); Martin (1994); Mähl et al. (2007, 2010); Palmstorfer (2007); Pundt and Schyns (2005); Resnick (2006); Resnick et al. (2009b); Resnick (2009); Rosseburg (2009); Sternberg (1999); Urban (2004); Vester (2009); Woodman et al. (1993).

Trait	Examples
Authentic	Doesn't hold back own ideas just to conform or to please others
Communicative	Doesn't manipulate, expressive, is able to explain own ideas
Collaborative	Pursues common goals, seeks common agreement
Considerate	Active listening, humility, takes foreign ideas into account
Fearless	Doesn't stigmatize mistakes, is not ashamed of own ideas, tries something new even at risk of failure
Diverse	Avoids or plays with expectations, aware, doesn't take something for granted, curious, open to something new, playful
Empathic	Helps weaker team members, recognizes interests of others, sees that everyone is involved
Expertise	Specialized in some way, usually by knowledge or skills
Imaginative	Ability to imagine situations, play them out mentally and describe them to other people
Positive attitude	Excited, faithful, humor, inspiring, no bias, not repressive, passionate
Proactive	Doesn't leave unpleasant work to others, doesn't rely on repetitive solutions, self-dependent
Reliable	Dependable, honest, trustful
Self-efficacy	Is able to suggest own ideas and confident to implement them
Tolerant	Accepts talents, spleens and quirks, respectful
Willing to compromise	Is able to discuss, neither avoids conflicts nor seeks them

Table B.3.: Desirable traits of interdisciplinary team members in creative projects. See also section 4.1 on page 27

Trait	Description
Aware	Discovers impediments
Associated	Provides information between other people
Equal	Has no authority to give directives
Mediate	Moderates meetings, facilitator
Reserved	Doesn't get involved into the actual project work
Respectful	Respects others and be respected by others
Result-oriented	Seeks maximum benefit and continuous improvement
Supervising	Checks that Scrum is used as intended, enforcer of rules
Supportive	Removes impediments, team building

Table B.4.: Requested traits of agile project managers (on the basis of the Scrum Master). See also section 4.2 on page 28

Trait	Explanation
Adaptable	Individual treatment in regard to speed, knowledge and talent
Associated	Links between people, maintains links
Aware	Discovers impediments
Balanced	No obsessive demands on oneself, not being everybody's darling
Brave	Gives up authority, criticizes if necessary
Calm	Isn't easily provoked (e.g., by silly or strange questions)
Curious	Welcomes change, is open to something new
Empathetic	Recognizes what motivates other people
Encouraging	Appreciates efforts, ideas and talents
Equal	Avoids instructions, sees that nobody is neglected
Future-oriented	Can-do-optimism
Individual-oriented	Supports continuous self-improvement, personality development
Passive	Controls indirectly, no anticipated solution patterns
Respectful	Treats questions seriously and, if necessary, with humor
Sociable	Connects, negotiates, mediates
Spontaneous	Quickly responds to the unexpected and surprising
Tolerant	Slow to judge and quick to encourage, without bias

Table B.5.: Requested traits of team managers who support creativity. See also section 4.2 on page 28

C. Creative climate

Climate is perceptible but not measurable in a traditional sense such as temperature (Urban, 2004). However, several questionnaires have been developed to measure creative climate:

Source	**Factors**
CCQ by Ekvall et al. (1999) http://soqonline.net	challenge, conflict, debate, freedom, idea support, idea time, playfulness and humor, risk-taking, sufficient resources, supervisory arrangements and work group supports, tolerance for uncertainty and ambiguity, trust and openness
Dolphin Index (based on CCQ) http://dolphinindex.org	commitment, dynamism, freedom, idea-proliferation, idea-support, idea-time, pay recognition, playfulness, positive relationships, risk-taking, shared view, stress, work recognition
KEYS by Amabile et al. (1995); Amabile (1996b)	challenging work, freedom, organizational encouragement, organizational impediments, sufficient resources, supervisory encouragement, work group supports, workload pressure

Table C.1.: Factors that influence creative climate. See also section 6.2 on page 59

Please note that the impact of these factors depends on the particular project phase: creative climate is most fertile at the beginning but declines gradually because of increased disagreements, failures, complexity, and loss of motivation (Damanpour, 1991). Moreover, several researchers have found no coherent correlation between mood and creativity until now (Amabile and Hennesse, 2010).

D. Creative environment

Source	Factors
Amabile (1996a)	sufficient resources, encouragement, formal mechanisms for creative work, no threatening evaluation, interdisciplinary, collaboration, recognition of creativity, failures acceptance, less separation, feedback, time to think creatively, challenge, pressure, competition, meaningful work
Herbig et al. (2008)	encourage risk taking, free exchange of ideas, stimulate participation, rely on intrinsic rewards, information flow, small team size, less hierarchy, less separation, democratic decision-making, less evaluation, recognition of creative work, frequent comfortable communication, keep away impediments, no strict control, less formal structures, less formal procedures, flexibility, willing to change
Lassig (2009)	challenge, constraints, evaluation, competition, cooperation, role models
Resnick (2006); Resnick et al. (2009b)	intrinsic motivation, interdisciplinary, less separation, collaboration, less formal structures, less formal procedures, sharing, time to think creatively, computer aided creativity, community, respect, trust

Table D.1.: Environmental stimulants to creativity. See also section 6.2 on 61

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