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Problem Discovery as a Collaborative, Creative, and Method-
Guided Search for the “Real Problems” as
Raw Diamonds of Innovation

by

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**Problem Discovery as a Collaborative, Creative, and Method-Guided Search for the
“Real Problems” as Raw Diamonds of Innovation**

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Abstract

This paper poses that the *creative search for frequently hidden “real” problems* is critical if innovation aims at comprehensive system improvements and changes in thinking paradigms, rather than simple, incremental changes. These hidden real problems can perhaps best be symbolized by raw diamonds, which one strives to find in order to then grind them into sparkling diamonds, i.e. innovation. Currently, problem solving-related research focuses on the analysis and solution of predefined problems, with little emphasis on problem reframing and systemic discovery; moreover, inter- and transdisciplinary collaborations for problem finding and the application of convoluted methods receive little attention. To illustrate the search process for raw diamonds, i.e. the real problem, by way of example, a comprehensive “*toolbox of convoluted methods*” is applied as part of a comprehensive problem discovery process. The *Planetary Model of Collaborative Creativity (PMCC)* serves as the conceptual basis for this method-based search for the real problems. It shows that this toolbox requires 1) *Collaborative effort*; 2) *Comprehensive competences* (personal, professional domain, systemic, creativity, and sociocultural competences); and 3) *A circular creative problem solving process*, which is embedded within a *sequential working process*.

Keywords: Toolbox of convoluted methods; Complex real-world problem; Innovation; Creative problem discovery and reframing; Knowledge integration; The Planetary Model of Collaborative Creativity (PMCC); Competences.

1. Introduction

When solving problems, dig at the roots instead of just hacking at the leaves.

Anthony J. D'Angelo

The *hypothesis* underlying this paper is that creative thinking – which is essential for innovation – is necessary already during the initial discovery of the underlying “real” problems, and not only during the search for solutions (i.e. innovations); this early use of creative thinking can also enhance the quality of mental representations of complex real-world systems and their embedded problems. In other words, an improved perception of underlying problems may directly affect the quality of any resulting innovations.

Innovation is critical for national growth rates and the *viability and competitiveness of societal systems* of various scopes, ranging from organizational to meta-national innovation systems (e.g., Schumpeter, 1934; Lundvall et al., 2002; Freeman, 2002; Baumol, 2002; Goel et al., 2004; Lundvall, 2010; European Commission, 2010, 2012; World Economic Forum, 2011; OECD, 2012). When Schumpeter (1934: 65-66), in his profound work on economic development and innovation, defined development as discontinuously appearing “*new combinations of productive means*” (i.e. materials and forces), either “to produce other things, or the same things by a different method”, he laid out a general and still widely accepted proposition of innovation-based development which applies to various levels of the societal *innovation system* and which goes beyond mere products, services, and processes. It is the role of the innovators (e.g., the entrepreneurs and/or the policymakers), as the change agents within such systems, to orchestrate individual and collaborative forces (and their analytical-logical and associative-intuitive thinking capabilities) in a way that they (1.) provide for a deepened and broadened understanding of the complex system and associated problems and (2.) discover new and applicable solutions for specific challenges (either initial or hidden problems), which contribute to the well-being of stakeholders (e.g., ranging from an improved utility-function of a product, service, or process, to enhanced

competences of smallholder-farmers in Africa as part of a national strategy to facilitate entrepreneurial agriculture in order to provide economic or social *value*).

Innovation, besides being a driver for competitiveness, is increasingly viewed as a vehicle towards *meta-objectives of a society* within a progressively globalized and interlinked world: a necessary means to attain food security (e.g., Juma, 2011), and most newsworthy, a *counter measure to crises* (e.g., OECD, 2009, 2012; European Commission, 2010, 2012; Steiner et al., 2013, 2014), as well as ultimately, part of a *future strategy* aiming towards *sustainable development* (e.g., Cash et al., 2003; Kirschten, 2005; Charter and Clark, 2007; Kemp et al., 2007; Nill and Kemp, 2009; Steiner, 2009; Smith et al., 2010; Loorbach et al., 2010; Boons et al., 2013). Innovation does not merely refer to technological, structural, and social innovation at the organization level, but, at the *micro-level*, encompasses also *citizen-driven innovation*, and, at the *macro-level*, *policy-innovation* as two extremes within the whole societal system. Hence, various parts of society are increasingly becoming potential *sources of innovation*, a perspective, which goes far beyond the enterprise. These tendencies further emphasize the interrelatedness of problems and innovations at meta-levels of society (e.g., policy innovations) with smaller-scale problems and innovations (e.g., product and service innovations from enterprises) and call for *reciprocal understanding*, in order to increase the quality of the various innovations.

Creativity is widely recognized as a precondition for innovation (e.g., Utterback, 1994; Lubart, 1994; Ford and Gioia, 1996; Amabile, 1996, 1997; Sternberg and Lubart, 2002; Sternberg, 2003; Runco, 2004; Steiner, 2009, 2011). Generally speaking, creativity may encompass different systemic aspects: the *creative personality*, the *creative product* (i.e. solutions), the *creative process*, and the *creative press* (i.e. various forms of pressure, which are imposed by the environment on the creative person) may be related to domain differences (Runco, 2004). While the creativity myth still widely holds that creativity is a “god-given” gift, other scholars have pointed out that *creativity can be influenced and even developed* (e.g., Lubart, 1994; Sternberg and Lubart, 2002; Sternberg, 2003; Runco, 2004) as well as *supported by creativity techniques and problem solving methods* within the creative problem solving process (e.g., Schlicksupp, 1993, 1999; Higgins, 2006; Steiner, 2007a, 2007b, 2011). In addition, the fundamental

creative potential of an individual can be tied to various *environmental dimensions*, such as a person's family socioeconomic background (Runco, 2004: 669). ***Creativity research*** is characterized by an overwhelming focus on the individual, and by an underrepresentation of ***research at the collaborative level*** (e.g., group, organization, network/cluster, regions), or *multilevel investigations* (Paulus and Nijstad, 2003; Sternberg, 2003; Steiner, 2009). As Simonton (2003: 320) points out, creativity must be viewed as a complex phenomenon “that occurs at multiple levels, from individuals, interpersonal interactions and problem solving groups to cultures, nations, and civilizations.”

The need for *collaborative* problem solving and *creativity at various societal levels* (which goes beyond *creative individuals*) has previously been emphasized by several innovation approaches as they focus on various stakeholders and aspects of the *societal innovation system*: e.g., *(lead) users* and *user communities* as functional sources of innovation (von Hippel, 1986; 2002, 2005; Tuomi, 2002; Edvardsson et al., 2012), *open innovation* approach for the integration of internal and external knowledge (Chesbrough, 2003, 2006); *transition management* which incorporates the society for sustainable societal transformations (Rotmans et al., 2001; Geels, 2002, 2006; Loorbach, 2007; Kemp et al., 2007; Loorbach et al., 2010) based on *democratic* and *multi-level governance* (Scharpf, 1994, 1999; March and Olsen, 1995; Hooghe and Marks, 2001), *social innovation* based on network learning in communities (e.g., Goldsmith & Eggers, 2004; Goldsmith, 2010), *citizen-driven innovation* to utilize the innovation potential of society in dealing with complex real world problems (Vigier, 2007; Steiner et al., 2013, 2014), and *inter-and transdisciplinary problem solving* to enable a joint problem solving across mutual learning among members of science and society (Scholz and Tietje, 2002; Steiner and Posch, 2006; Scholz, 2011). Despite the increased attention that collaborative approaches have previously gained, ***extended research is required, related to social and behavioral aspects of knowledge integration*** (e.g., Grant, 1996; Scholz and Tietje, 2002; Scholz, 2011; Berggren et al., 2011), ***particularly regarding various scientific disciplines, the inherent expertise of science and society, the synthesis of analytical-logical and associative-intuitive thinking modes, and – of increasing relevance in a globalized and highly interdependent world – the coming together of cultural and religious characteristics.***

Although literature widely agrees on the necessity of creativity for idea generation as part of creative problem solving and innovation processes, ***problem discovery and particularly the role of creativity for problem discovery have remained underrepresented topics within the substantial literature on problem solving***. Notable research efforts on problem discovery can be assigned to the work of Getzels and Csikszentmihalyi in the mid 70ies (Getzels and Csikszentmihalyi, 1976). Subsequently, Runco and colleagues contributed to a better understanding of problem discovery and its influence on creative performance, suggesting that *discovered problems* give more opportunity to think about the problem and, consequently, may result in more responses than presented problems (e.g., Runco and Okuda, 1988; Runco, 1994). Whereas most research on problem finding is limited to psychological experiments (e.g., Runco and Okuda, 1988; Runco, 1994, 2004) and, more recently, also in conjunction with brain research (e.g., Dandan et al., 2013), ***problem finding has not been a focus of observational studies and cases in real world settings*** (e.g., Moore and Murdock, 1991; Chand and Runco, 1991). Such extended research effort seems to be particularly beneficial for innovation and technology research.

Furthermore, there is also a ***lack of literature on methods for problem finding***, although potentially helpful methods can be found as segments within the general field of applied problem solving techniques (e.g., Schlicksupp, 1993, 1999; Higgins, 2006) and various other disciplines such as, e.g., design studies/ design methodology (e.g., IDEO, 2011; Heufler, 2012; Steiner and Scherr, 2013), systems thinking and systems modeling (e.g., Forrester, 1961; Beer, 1972; Checkland, 1981, 1999; Senge, 1990; Flood and Jackson, 1991; Sterman, 2000; Schwaninger, 2004; Mulej, 2007; Meadows, 2008; Steiner et al., 2013, 2014), and future studies (e.g., Jungk and Muellert, 1987, 1997; Hines and Bishop, 2006; Bishop and Hines, 2012), without providing a common framework of methods though.

This paper is organized as follows: After an introductory overview of existing definitions and approaches (Section 1), Section 2 starts with a brief characterization of complex real world problems (e.g., most innovation problems), outlines the interplay of convergent and divergent thinking processes within problem discovery, and stresses the relevance of collaborative approaches in problem discovery. Based on these dimensions, Section 3 introduces the *Planetary Model of Collaborative Creativity*, as the

conceptual framework for a method-guided problem discovery process as described in Section 5. Section 4 reviews selected collaborative methods applied by analyzing its characteristics related to creative problem discovery. Section 5 outlines a comprehensive problem discovery/-solving design as applied in several real-world cases. The final section summarizes key findings and discusses directions for future research.

2. The search for hidden problems as the cradle for creativity from a cognitive perspective

I believe in intuition and inspiration. Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution. It is, strictly speaking, a real factor in scientific research.

(Einstein, 1931: 97)

A thorough understanding of the underlying system and its embedded problems is crucial for *knowledge integration and generation* as part of a comprehensive problem solving process (e.g., Ackoff and Rovin, 2005; Scholz and Tietje, 2002; Scholz, 2011), and, since it *enhances mental representations* of the system and its embedded problems (Steiner, 2013), will, at least, partly, determine the quality of the solution (i.e. innovation) (e.g., Runco and Okuda, 1988; Chand and Runco, 1993; Hu et al., 2010). Therefore, the real problem or true cause of a symptom, once discovered, functions as the “lighting house” for future/scenario thinking and strategic foresight. As noted by Hines and Bishop (2006), “Far too many strategic foresight activities – and business analyses in general – end up addressing and “solving” the wrong problem [...]”, therefore a *framing* and *reframing* of the scope and focus of the problem is needed as part of problem discovery.

2.1 Innovation problems as complex real-world problems

Innovation problems are real-world problems of *complex* nature, i.e. they are multifaceted, ill-defined, nonlinear, with innumerable sets of highly interdependent subsystems and elements, and they reveal dynamically changing development patterns over time (Sterman, 2000: 3-39; Scholz and Tietje, 2002: 34; Meadows, 2008: 181-182; Steiner, 2013: 18). Generally speaking, innovation problems distinguish themselves from other problems in that they focus on *future developments*, are based only on a blurred understanding of both the changes that their environment will undergo and the types of future stakeholders (including customers) they will likely face, and hence, in that they are based on a variety of associated *uncertainties and risks*. Because the “*real problem*” takes these innovation characteristics as much as possible into account, it is an extremely important source of innovation.

The problems we have to deal with or which need to be discovered and which, consequently, serve as *source of innovation*, are embedded within a globalized and highly interdependent world. To overcome a *system-caused problem*, the system itself as well as its boundaries, how it functions and malfunctions, and how it is interrelated with its environment, need to be thoroughly understood (e.g., Runco, 1994; Scholz and Tietje, 2002; Ackoff and Rovin, 2005). Based on a deepened *systems understanding*, this paper focuses on the search for the “*real problems*”, particularly those problems, which exhibit the properties of “*raw diamonds*” for subsequent innovation. The underlying assumption is that an *extended knowledge about the historical and contemporary roots of the (initial) problem(s) and the system in which they are embedded leads to and improved quality of future outcomes (as innovations)*. Such “real problems” are usually not obvious and tend to be hidden from the problem solvers; hence, they often need to be critically and *creatively (re)framed or discovered* as the problems behind the initial problem(s) and symptom(s) (e.g., Runco, 1994; Csikszentmihalyi, 1996a; Henriksen, 2001: 597; Huebner, 2002: 277-279; Ackoff and Rovin, 2005; Steiner, 2009, 2011). In other words, observable *symptoms* can be different from the underlying causes.

The extent to which a *problem* can be considered a *source for creativity* (and consequently for innovativeness) varies greatly. However, a general distinction can be made with regard to a problem's complexity. *Complex problems* tend to be of *ill-defined* nature and can rarely be solved by means of standard solutions (e.g., Kitchener, 1983: 223; Schraw et al., 1995; Jaarsveld et al., 2010; Scholz, 2011; Steiner, 2011); instead, their ill-defined nature already points to the ambiguous state of the contemporary system in which such problems are embedded and the dynamic interdependency of the system with its relevant environment. Consequently, not only potential solutions call for creativity, but creativity is also needed for gaining a deepened understanding of the complex system and its embedded problems. By contrast, if appropriate *standard solutions* are available (such as for well-defined problems, encompassing both simple as well as complicated problems), there is no obvious reason to look for new approaches, particularly if stakeholders are satisfied with these standard solutions. However, from an innovation perspective, even a simple "system" such as a chair could be viewed as a starting point for an innovation endeavor, given that – as soon as the chair is viewed as a means to fulfill extended functions within a multi-faceted socio-technological or socio-cultural environment – it could quickly turn into a complex problem.

Let's consider the following case: The initial problem in a new product development for the cleaning industry is to come up with new equipment for cleaning the exterior facades of private homes. If one considers precisely this initial problem as the basis for new product development, there is a high probability that the outcome will be related to mostly incremental innovations: For example, the new product might demonstrate improved cleaning performance by utilizing cutting-edge cleaning technology, or it might be "smarter" by making use of new information and communication technologies. It might simply be more appealing, or show an additional luxury feature such as using sophisticated sensors to measure the degree of pollution of the facade to be cleaned. Hence, even though the underlying technologies might be considered cutting-edge (e.g., a laser-based optical technology for pollution detection), all these examples are still only based on

incremental improvements in cleaning technology. If one wants to go beyond the initial problem, a guiding question with a completely different orientation might emerge. Such potentially surprising guiding questions in our cleaning industry case might be: “How can we keep house facades clean (eliminating the need for cleaning all together)?” Or “What is the cultural and historical meaning of dirt and cleaning, and how can we harmonize cleaning with our daily activities (e.g., leisure time activities)? How can behavior patterns that are associated with pollution be better understood, and subsequently be changed? Which direction might cultural and historical implications and behavior patterns take in future?”

In the example of practical innovation projects, the *initial problem* is primarily useful in that it enables a first orientation within the innovation process. But it almost always requires further analysis and a deeper understanding of the “real” problem, potentially even necessitating a complete *reframing* of the original problem. As an intermediary result of reframing the initial problem(s), an overarching or *guiding question* may emerge (see the example in the paragraph above), which can help draw the attention to the core problems within a given system of investigation (e.g., Scholz and Tietje, 2002; Scholz, 2011). Overall, newly *discovered problems* tend to be considered “*real problems*” if they help understand what really matters to *present and/or future stakeholders* (e.g., Steiner, 2008, 2011) and if they carry the potential for (radical) innovations, as solutions to the initial problem(s).

2.2 Knowledge integration (and generation)

From the perspective of *knowledge integration*, collaborative problem solving approaches aim to synthesize different types of complementary knowledge in a goal-orientated process, which in its broader meaning also encompasses *the generation of new knowledge* (Scholz and Tietje, 2002; Scholz, 2011; Berggren et al., 2011). Knowledge integration, by being related to society and environment as multidimensional systems, can provide orientation and guidance within the problem solving process and,

as its subsystem, within the problem discovery process. As a multidimensional concept, knowledge integration includes the following aspects (Scholz and Tietje, 2002; Scholz, 2011): (1.) Integration of different scientific disciplines (i.e. interdisciplinarity), (2.) Integration of various forms of natural systems (e.g., water, air, and soil), (3.) Relating different types of knowledge or epistemics (based on various modes of thought such as intuitive or an analytic modes), (4.) Integration of different perspectives, values, and preferences of different stakeholders (i.e. as part of social systems), and (5.) Interrelation of different cultures. Whereas all five dimensions are relevant for knowledge integration in a real-world context, from a behavioral perspective and for the purpose of providing orientation for the analysis of approaches aimed at a process- and method-guided search for the “real” problems and, consecutively, the search for future solutions, (1.), (3.), (4.), and (5.) are of particular interest. From the perspective of problem discovery, firstly, the interplay of convergent and divergent thinking – i.e. (3.) – and, secondly, inter- and transdisciplinary collaborative processes – i.e. (1.), (4.), and (5.) – will briefly be discussed.

2.2.1 *Creative thinking for problem discovery: the interplay of convergent and divergent thinking*

The potential of creativity for problem discovery and systems understanding has, to date, not yet been fully appreciated. In order to argue for an important role of creativity in problem discovery, it is helpful to start with a definition of *creative thinking*. If, as suggest by Runco (1994b), *creative thinking* is understood “[...] in terms of the cognitive processes that lead to an original (e.g., novel, unique, or highly unusual) and adaptive (e.g., fitting, useful, or apt) insight, idea, or solution”, it becomes quickly obvious that the outcome not only comprises potential solutions, but also *original or adaptive insights* related to (either hidden, not obvious, discovered, or real) problems, which, in turn, can help to further enhance the quality of the problem discovery process and hence, grasp of a problem.

Wallas (1926), in his groundbreaking work based on *Poincaré* (1913), defined the *four-stage creativity process*, which, according to him, consists of *preparation, incubation, illumination, and verification* and this definition is, to date, widely regarded as a cornerstone for creativity research and creative problem solving. Granted, the linearity of this process might appear questionable today, since the

four individual phases tend to more often occur in a *recurring and interdependent* manner (e.g., Runco, 1994; Csikszentmihalyi, 1996a; Steiner, 2011). However, it is particularly important to recognize that Wallas' model helped focus the attention of creativity research on the interplay between *consciousness and unconsciousness* in which the creative problem solving process takes place. An important *implication as far as problem discovery* is concerned is that the two phases *analytical-logical thinking during preparation, and associative-intuitive thinking during incubation, are interwoven and recurrent phases*, which, in their interplay, ultimately lead to *illumination as the discovery of the hidden, real problem - or the raw diamond of innovation*.

To comprehensively grasp the “*real*” *problems* embedded within complex real-world systems (including their interdependences and dynamically changing patterns) and, ultimately, to employ these problems as sources of innovation, *associative-intuitive thinking* (i.e. divergent thinking) is needed in addition to *logical-analytical thinking* (i.e. convergent thinking), in order to approach the initial problem from *different viewpoints*. A well-known example was provided by the adolescent Einstein, who imagined himself chasing a beam of light, as part of his famous thought experiment; an associative thought experiment, which ultimately led to Einstein's discovery of the special theory of relativity.

Though *guiding questions* (e.g., in the earlier example of the cleaning industry) can be tremendously helpful in realigning a problem solving strategy, if one wants to uncover the “*real*” problems, a *dynamic interplay between convergent and divergent thinking as part of one creative process* appears to be necessary (e.g., Guilford, 1959; Getzels and Jackson, 1962; Hudson, 1972; Runco, 1986; Csikszentmihalyi, 1996a, 1996b: 38; Steiner, 2009, 2011). Similarly, while *creative thinking* tends to get linked primarily with divergent thinking, convergent thinking is another equally necessary ingredient. In fact, it is the interplay of *logical-analytical thinking patterns* with *associative-intuitive thinking patterns*, which characterizes creative, goal-oriented thinking processes and is needed as early as during the search for, and exploration of, the underlying and hidden real problems as the raw diamonds of innovation. Logical-analytical thinking patterns (as part of rational reasoning) are especially meaningful to structure the creative search for the “*real*” problems and to make sure that the problems are of relevance for

problem solving agents and for stakeholders. As for any discovery, it seems just reasonable to pay attention to the underlying problems and to the process that helps to make them more visible. Hence, if creativity is successfully applied for problem discovery, *problem reframing* based on *extended perspectives, intuition, and enriching associations* has the potential to lead to a higher quality of the problem discovery process, which consequently enables creative thinking processes to become more powerfully targeted at the search for creative ideas and solutions as the next phase within the creative problem solving- and innovation process.

2.2.2 *Collaboration for problem discovery: inter- and transdisciplinarity*

Collaborative problem discovery as part of a more comprehensive overall problem solving process draws on the collective *creative and rational forces* of a team, for a *deepened and broadened* understanding of the complex system and its associated problems. In order to better understand and manage the capacity of collaborative approaches when dealing with complex real-world problems, it is useful to distinguish between the more widely known collaboration among different scientific disciplines (i.e. interdisciplinarity), and collaboration between science and the non-scientific world (i.e. transdisciplinarity). While the latter is increasingly gaining interest, particularly among practitioners but also among scientists, it is still not sufficiently understood. E.g., how do *heterogeneous mental representations* of the various stakeholders regarding underlying systems and their embedded problems (i.e. the mental models) influence collaborative behavior patterns? How can the *communication* between the collaborating agents be improved? And which *methods* are most supportive and appropriate for the problem solving/discovery process?

Interdisciplinarity refers to scientific forms of collaboration, which bring together concepts and methods from various different scientific disciplines in order to overcome the limitations of single disciplines when dealing with complex and broad problems and topics (Klein and Newell, 1997; Steiner and Laws, 2006: 325; Scholz, 2011). Analogous to a puzzle, single disciplines might contribute particular image sections, but in order to comprehend the whole picture, an interdisciplinary effort might be needed.

The involvement of societal stakeholders becomes increasingly important when *opening up innovation paradigms and –processes*, and allowing them to *synthesize and utilize internal as well as external creativity and innovation potential* (e.g., von Hippel, 1986, 2002, 2005; Tuomi, 2002; Chesbrough, 2003, 2006; Vigier, 2007; Edvardsson et al., 2012; Steiner et al., 2013, 2014). According to Scholz (2011: 385), transdisciplinarity encompasses the following functionalities: capacity-/competence-building, consensus building, analytic mediation, and legitimation (for an extended explanation of transdisciplinarity see Scholz, 2011: 373-404). *Transdisciplinarity, by definition*, enables mutual learning by science and society (i.e. the non-scientific world) through the *incorporation of problem solving agents' knowledge and values* as part of a collaborative effort to solve complex real-world problems; this includes the understanding of the complex system as well as the discovery of the “real” problems (Scholz and Tietje, 2002, Steiner and Laws, 2006; Steiner and Posch, 2006; Scholz, 2011).

To conclude, from a *systems perspective*, the increasing complexity of systems and their embedded problems implies an increasing number of interdependencies and potential solutions. Consequently, *a higher awareness about these interdependencies leads to higher awareness of potential problems, and ultimately, enhanced quality of potential solutions*. To discover the oftentimes hidden structures and patterns of the system/problem, creative thinking processes can help gain an enhanced mental representation of the complex system and embedded problems. Ultimately, creative thinking (i.e. the joint process of logical-analytical and associative-intuitive thinking modes) does not substitute for, but rather, improves the quality of the mental representations of an external world that were gained through rational reasoning. To *operationalize the search* for the “real” problems as raw diamonds of innovation, we need to understand the importance of an appropriate working process design and of the goal-oriented application of collaborative *working methods* in this search. Therefore, in the following, I review selected methods and their suitability for creative problem discovery; these insights, together with the previous sections, then serve as the basis for a subsequent application within a comprehensive problem discovery/-solving process.

3. A framework for method-guided problem discovery: The Planetary Model of Collaborative Creativity (PMCC)

Given our main aim, i.e. to shed light on a method-based search for real problems, we need a properly *designed working process* to support this search. This is particularly important since, within this paper, we describe the process of problem discovery as a sequence of recurring working steps within a circular problem solving process in which a variety of methods is applied (sometimes in a repetitive manner). In order to provide a consistent *storyline of multiple methods* applied along this creative problem solving process and following the arguments made within preceding sections of this article, the underlying process model needs to fulfill the following requirements: (1.) represents a circular, feedback-based (forward and backward), and interdependent creative problem solving process (i.e. allowing a back and forth between single working steps, e.g., the initial problem not only influences the development of partial solutions to a problem, but conversely might lead to an extended understanding and a reframing of the initial problem); (2.) Problem discovery respectively problem finding as an explicit part of this process in order to avoid superficially dealing with symptomatic problems only; (3.) serves as a playground and supports the dynamic interplay of convergent and divergent thinking (see Section 2); and (4.) is an overlaying sequential working process which ultimately should lead to innovation.

Although the creative problem solving process has been of some research interest in the organizational innovation literature, particularly since the 1980ies (e.g., Thom, 1980; Vahs and Burmester, 1999, 2005; Davila et al., 2005), *creative problem discovery* has widely been neglected; hence, *method-guided* problem discovery processes have not been a focus either. Instead, creative processes have primarily been associated with *idea generation* as one phase within a comprehensive innovation process. Similarly, method-based support of creative processes has only been of marginal interest within *creativity research* (e.g., Osborn, 1963; McFadzean, 2000; Litchfield, 2008), whereas method-guided problem solving has received more attention within the *applied literature of engineering*,

industrial design, management, and future studies (e.g., Jungk and Muellert, 1987, 1997; Geschka and Yildiz, 1990; Schlicksupp, 1993, 1999; Higgins, 2006; Hines and Bishop, 2006; Steiner, 2007a, 2007b; IDEO, 2011; Heufler, 2012; Steiner and Scherr, 2013). *Systems science* (with systems thinking and systems modeling as subdisciplines) is still vastly underrepresented in the creative problem solving, creativity, and innovation literature, yet this discipline might offer many different new perspectives and methods to be applied for problem discovery. Such new approaches include, for example, systems dynamics (e.g., Forrester, 1961; Senge, 1990; Sterman, 2000; Meadows, 2008); soft system methodology (e.g., Checkland, 1981, 1999); and (socio)cybernetics as well as integrated methodologies (e.g., Beer, 1972; Flood and Jackson, 1991; Jackson, 2003; Schwaninger, 2004; Mulej, 2007; von Foerster, 2010).

Further, it is often assumed that *problems* are *given* or must be *presented* (e.g., as part of a work assignment or a project outline) which, from a practical perspective, is an unrealistic assumption, since *additional and repetitive working steps* might be needed (e.g., system immersion as part of system analysis) in order to discover, analyze, and define a particular problem. In addition, *creativity and innovation processes* are widely understood as *sequential phases* which occur in a nonrecurring manner, a simplification which, if applied, limits the potential to make use of the creative and innovative capabilities of collaborating agents. E.g., particularly the creative process according to Wallas (1926) widely influenced theoretical and practical attempts to “manage” creativity; however, its real value lies in presenting a general basis for a better understanding of the individual building blocks of a creative process rather than describing a creative real-world collaboration process. Notable exemptions, which outline a circular process design are, e.g., Isaksen et al. (2000), and Buijs (2003). Additionally, an *agent-focused and a process-phase-specific stakeholder management* are widely missing (with respect to purposefully considering stakeholders but also involving them as potential problem solvers at specific phases of the collaborative problem solving process).

The Planetary Model of Collaborative Creativity (PMCC), which is used as a framework for method-guided problem discovery (as outlined in Section 5) is a *circular model* (i.e. and it therefore serves as the epistemological basis for problem discovery as part of a comprehensive creative problem solving

process). This model, which evolved over the past 15 years (and which has been tested and further refined through real life applications within various innovation projects), has several fundamental objectives: it should be exceptionally suited for applications within real-world innovation processes, should accommodate heterogeneous stakeholder involvement (i.e. inter- and transdisciplinary), focus on the circularity within a collaborative process, and provide a method-guided working process. The following description compresses, builds on, and further advances the underlying basic version of the model, which was introduced by Steiner (2011). Based on a sociocybernetic approach, the Planetary Model of Collaborative Creativity serves as the guiding framework in efforts to uncover “real problems” which has/have the potential to become the creative spark respectively the raw diamond for innovation development.

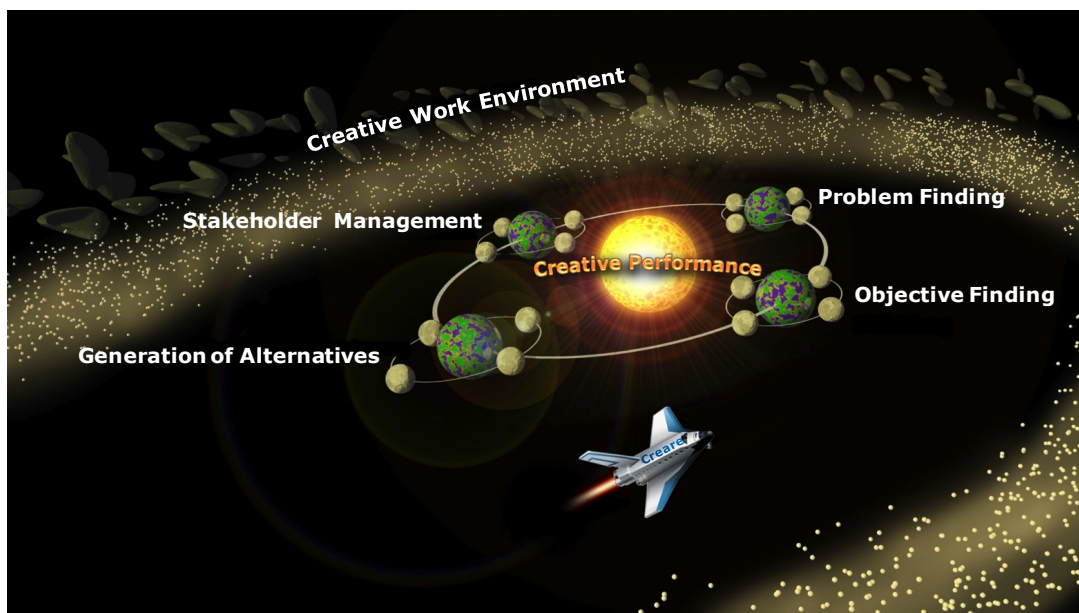


Figure 1. The Planetary Model of Collaborative Creativity (PMCC)

(based on earlier versions Steiner, 2009, 2011)

The PMCC makes only metaphorical use of the planetary system (i.e. without claim for astrophysical rigor), aimed at providing guidance along the process of creative problem solving in a collaborative setting (Steiner, 2011: 65-156):

As outlined in Figure 1, the spaceship “Creare” (Latin: kre'are, in reference to its mission of creatively exploring the unknown) explores a planetary system, which consists of the sun, surrounded by four planets and their moons, and a cosmic ring which encircles the sun, planets, and moons. On its expedition, the space ship Creare does not approach each single planet (including their moons) and cosmic ring in a sequential manner; rather, the mission takes place in a *recurrent mode*, which is perfectly fitted to appropriately tackle the circularity of a creative problem solving system. All interrelated planets (i.e. metaphor for stakeholder management, problem finding, objective finding, and generation of alternatives) and moons represent the *primary problem solving system*, which is most directly affected by Creare’s crew (i.e. the collaborative problem solving agents). The creative work environment (i.e. the creative climate) as the *secondary problem solving system* represents a more stable dimension of the overall problem solving system, which can primarily be influenced only in the medium- and long-term. For example, leadership and organizational culture strongly influence problem solving patterns within a given system, but remain relatively stable across various projects. The same applies to more physical dimensions such as the infrastructural and architectural environment (including the design of suitable workplaces).

The *composition of the crew is not static*, but does have a stable core team consisting of the captain, first officer, and a few other crew members; however, the crew depends on the mission to be accomplished. In other words, the “*crew on duty*” is exchangeable and varies, depending on the innovation challenge (as well as its specific setting). It is also related to the particular tasks to be fulfilled within the problem solving process. Essentially, one can envision the crew as a collaborative team of internal and external stakeholders as well as experts from various disciplines and fields (i.e. the area of professional life). Its aim is to explore the previously unknown (i.e. the initially often hidden problems) and to develop innovations based on the unknown. In their attempt to enable *creative performance* (i.e.

the sun, as a metaphor), the crew ultimately ends up driving the development of all planets and moons by combining their potential and resources in order to develop (1.) a deepened understanding of the complex real-world system and its embedded problem(s), (2.) new solutions for the problem(s) (initial and/or discovered ones) based on specific objectives, (3.) ideas which are not immediately related to the underlying problem(s) (but which might be useful in the future either for this or other problems), and (4.) meta-knowledge which goes beyond the underlying problem(s) such as knowledge about the creative problem solving process itself or about learning processes in general (see also the definition of creativity in Section 1).

As an important *characteristic* of this model, *non-linearity* and *feedback* between all planets and moons allow for creative performance to occur at various planets and moons (i.e. at all stages of the problem solving process) and not only at the *Planet Generation of Alternatives* and its moons. For example, potential solutions might emerge as early as during the search for underlying, fundamental problems within a given system of interest, possibly because the problem solver, at this early point in time, is likely not yet affected or “brain washed” by the system; further, potential solutions and ideas can necessitate a reframing of the original problem. Lastly, *evaluation* and *selection*, either formal or informal, occur within the entire planetary system (i.e. for every planet with moons and for the cosmic ring) and are also not limited to “alternatives” only. For example, the selection of problem solving agents or the choice of specific creativity techniques and problem solving methods to be applied occurs at each stage in the creative process; moreover, the crew can change during the process (e.g., external stakeholders temporarily become active problem solvers), thereby affecting the perception of problems, but can also extend the problem focus, or even reframe a problem, In addition, an entire set of relevant objectives within the whole problem solving system can change; and completely new ideas might ultimately extend the innovation basis.

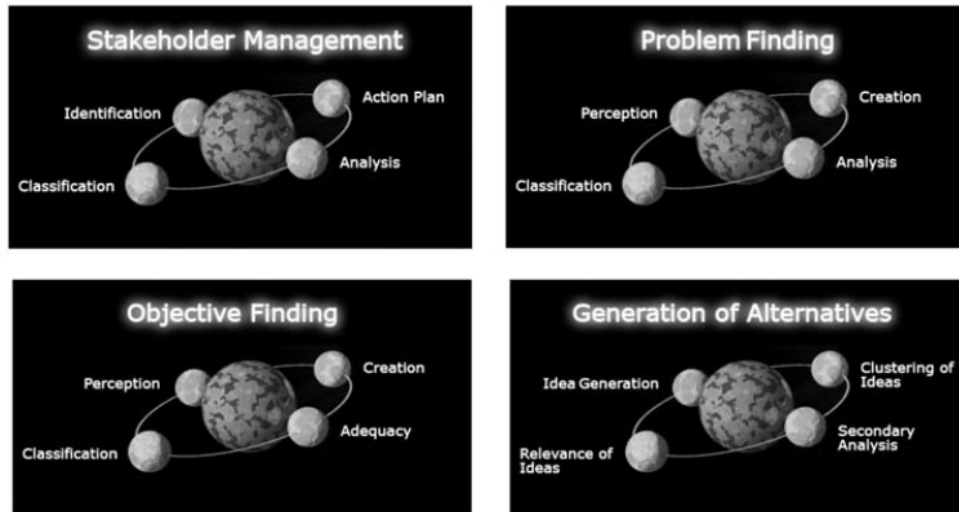


Figure 2. *The Planetary Model: Planets with Moons* (based on Steiner, 2009, 2011)

As outlined in Figure 2, each planet can be understood as a subunit of the whole problem solving system, which is dynamically interrelated with all other planets/moons, the sun, and the cosmic cloud. The planet *Stakeholder Management* is orbited by the moons *Stakeholder Identification*, *Stakeholder Analysis*, *Stakeholder Classification*, and *Stakeholder Action Plan*. Important questions that need to be asked in order to facilitate a creative process at this stage are, e.g., who are relevant stakeholders, how can they best be involved, and at what stages of the problem solving process? The planet *Problem Finding* is orbited by the moons *Problem Perception*, *Problem Creation*, *Problem Analysis*, and *Problem Classification*. Here, relevant questions to ask are, e.g., has the ‘real’ problem or the meta-problem been revealed, what can be done to discover it, which stakeholder-specific differences related to the problem perception exist, and is there a need to reframe the problem? The planet *Objective Finding* is orbited by the moons *Objective Perception*, *Objective Creation*, *Objective Adequacy*, and *Objective Classification*. Potentially relevant questions at this stage are, e.g., what are the relevant objectives of various stakeholders and problem solving agents in relation to the problem solving process, and are these objectives consistent with superordinate objectives of the system (e.g., of the organization or of society)? The planet *Generation of Alternatives* is orbited by the moons *Secondary Analysis*, *Idea Generation*, *Clustering of Ideas*, and *Relevance of Ideas*. Important question to ask here are, e.g., how can appropriate

ideas be generated, which methods may support this collaborative process, and how could one synthesize pre-existing solutions and newly created solutions?

3.1 The Spaceship and its Crew: Essential Competences

The Planetary Model of Collaborative Creativity and its application within a sequential working procedure offers an approach which helps to integrate (1.) *circularity* needed to deeply delve into a complex (i.e. ill-defined) real-world problem and (2.) *sequential order* which is the basis for “getting things done” in a real-world innovation context. This approach enables the spaceship Creare and its crew to dynamically use the creative capabilities of its diverse members based on stage-specific team constellations. However, to succeed on this uncertain voyage through a complex world and towards innovation, the Planetary Model also points out the need for specific competences of its crew members (see ‘essential competences’ in Table 3): “[...] systemic, creativity, and sociocultural (collaborative) competences are considered crucial in complementing personal and professional domain competences to tackle today’s complex real-world challenges” (Steiner, 2013). For a comprehensive overview of competence frameworks see, e.g., Wiek, et al. (2011) and Steiner (2013).

Since such a problem-solving framework requires comprehensive competences of involved problem solvers, strategies need to be developed to compensate for potentially missing competences. Usually, this will encompass a mix of short-, medium-, and long-term measures. In the short- and mid-term, an increase of internal or external problem solving agents is needed, either on a temporal or permanent basis. In the long run, appropriate educational measures, either in-house or through external training, are necessary to enhance the competences of the spaceship’s permanent and temporal crew.

3.2 Creare's Logbook: Implications for the Working Process

Feedback, circularity, and interrelatedness are crucial for the creative problem solving process; however, it is equally crucial to not get lost in endless circularity, but rather, to provide results, which represent a promising basis for successful innovation. Thus, *orientation based on a sequential order* is needed to overlay the creative problem solving process. This order is provided by Creare's *Logbook*, which is governed by the captain (facilitated by his core team) and provides direction on the spaceship's way through space as well as ensures that creative performances do not get lost, but can effectively contribute to innovation. The Logbook takes into account all characteristics of the specific mission and the interdependencies among planets, moons, and the cosmic ring, i.e. the individuality of every project and the specifics of the collaborative problem discovery and problem solving process form the basis for process planning and the design of appropriate methodological support. The suggested *sequential order* of the *innovation-oriented working process* is based on previous experiences. For this purpose, various sequential innovation models/processes might be taken as basis; they, together with the embedded Planetary Model, enable a fruitful synthesis of circularity in conjunction with sequential order as a means to reach a project goal within a reasonable time horizon. The chosen sequential process (see Figure 3), which serves also as the basis for the subsequent case description, consists of (1.) *System analysis*; (2.) *Conceptualization*; (3.) *Specification*; and (4.) *Selection and implementation* (this process was also applied in Section 5).

As a valid principle for every single working stage it can be assumed that the stakeholders to be involved as potential problem solvers in the collaborative effort will, most likely, change numerous times, from working stage to working stage, sometimes even within a single working stage. I.e. the crew of the spaceship Creare will keep changing throughout the whole working process with only a small permanent core team.

Within the first stage, *system analysis*, the focus is on analysis and understanding of (1.) potential system boundaries (besides physical, functional, and geographical boundaries, this also encompasses a

temporal dimension in an attempt to understand relevant future development patterns); (2.) subsystems and elements of the system, their interrelatedness, structure, and patterns of behavior along their development from initial to contemporary and potential future state; (3.) how the system is interrelated with its environment (requiring a comprehensive understanding of the interdependencies of the system with its environment at various levels, such as political, legal, & institutional; sociocultural; economic & financial; technological; infrastructural & architectural; and ecological dimensions); (4.) what the preferences and objectives of various stakeholders are; (5.) the initial and potentially hidden problem(s) from various stakeholder perspectives; (6.) values, mission, and vision of the meta-system (e.g., for the product this might be the organization; for the inner-state problem this might be the international community) and its coherence with the system's objectives and preferences. Beyond understanding, finally, this stage might also serve as a source for ideas and potential solutions as part of successful innovations.

Building on the insights gained during the first stage, within the second stage, *conceptualization* of the problems embedded in the underlying system serves as impetus for the generation of further ideas. These, together with ideas, which have been generated during the previous stage of system analysis, are bundled and synthesized to a set of single conceptions. Each conception is supposed to be related to relevant problems (obvious or hidden), thereby condensing creative solutions to a "first rough draft" with the potential to become an innovation, which will succeed in the future. Single conceptions will vary depending on a problem's focus, stakeholder preferences and objectives, as well as underlying future scenarios of the relevant environment. Thus, a concept is not merely a creative endeavor; instead, it is a link between a system with embedded problems and its environment.

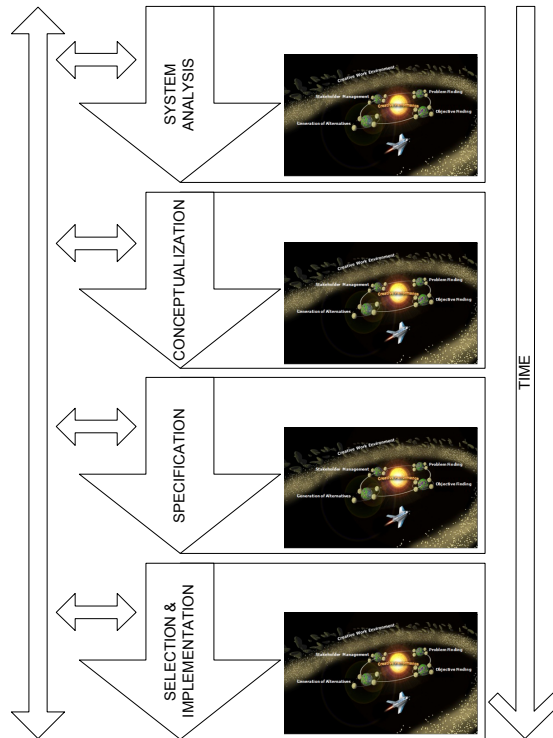


Figure 3. A Logbook-based Sequential Working Process (based on Steiner, 2009, 2011)

Specification, as the third stage of the working process, aims to reduce the number of concepts that need to be further advanced. Moreover, an in depth problem- and stakeholder analysis provides additional impetus for improved and more adequate and detailed solutions. At this stage it becomes increasingly relevant to refine the concept in order to be consistent with stakeholders' objectives and specific requirements. To enable such a fit, methods like e.g., rapid prototyping, personas, and storyboarding are increasingly applied, and their application could actually also be useful as early as during conceptualization.

During the stage of *selection and implementation*, concept/s is/are chosen, which is/are going to be functionally and technically further developed in order to provide a marketable innovation. In addition to innovation development and feasibility considerations, diffusion and adoption processes are now gaining increasing importance, as they are the vehicles to implement the innovation in the field (e.g., in case of

political innovations) or market (e.g., in case of a product innovation). Obviously this stage also extensively relies on adequate anticipation of potential problems that might occur during these processes, stakeholder preferences, consideration of operational and strategic objectives as well as the overall mission and vision, and the ability to develop creative solutions.

In summary, the Planetary Model of Collaborative Creativity is characterized by constantly newly compiled and adapted planets (i.e. each subsystem of the problem solving system) throughout each stage within the sequential working process. Consequently, also the problem will be reframed along the sequential working process, although this usually will increasingly concern parts and details of the system and its embedded problems. As the working process advances, the creative performance becomes more and more sophisticated and relevant to the underlying real-world problem. This is also true for the real problem as the raw diamond of innovation: It is highly unlikely to generate successful innovation without having deeply penetrated every stage of system analysis, which then ultimately serves as the cradle for identifying or discovering real problems with the potential to nurture creative performance and finally innovation.

4. Suitability of selected collaborative methods for creative problem discovery

Knowledge without understanding is a misguided missile.

(Ackoff and Rovin, 2005: 15)

As outlined in the Planetary Model in Section 3, problem discovery (i.e. problem finding) is not a preliminary stage of idea generation (i.e. generation of alternatives), but it is part of an iterative working process with recurring working steps during which a variety of methods are applied (sometimes in a repetitive manner). Because *collaborative approaches* have the potential to provide an extended

knowledge basis for problem discovery as part of the overall problem solving process (see outline in Section 2), *methods* in support of these approaches are discussed next. Some of these methods have a general scope of application, whereas others focus on specific stakeholders such as on customers. In this vein, Edvardsson et al. (2012), for example, provide a broad review of methods for customer integration within service development. With a particular emphasis on *participatory methods* for public involvement, Slocum et al. (2005) compiled a valuable overview of 13 prominent methods that can be applied in the planning, evaluation, and implementation phase; these methods include 21st Century Town Meeting; Charrette; Citizens Jury; Consensus Conference; Deliberative Polling; Delphi; Expert Panel; Focus Group; Participatory Assessment, Monitoring, and Evaluation (PAME); Planning Cell, Scenario Building; Technology Festival; and The World Café (for a more exhausting investigation on future research methodology see Glenn and Gordon, 2009). In the context of this paper, the term *collaboration* is used more generally, i.e. to point out that any problem discovery process extends well beyond individual efforts and is rather based on the joint effort of various agents, whereas *participation* refers specifically to the involvement of the public.

4.1 Comprehensive Collaborative Methods

Table 1 summarizes a selection of comprehensive collaborative *methods* for creative problem discovery and problem solving (as part of innovation generation) and provides a brief analysis of various dimensions of *knowledge integration*, as outlined above and, particularly, their potential contribution to *problem discovery/-(re)framing*. *Methods were selected* based on the following rationale:

- Based on either *creativity-/innovation-/technology management, systems thinking/-modeling, policy studies, design studies, or future studies*
- Relevant for *complex real-world problems* (including being capable to bridge *past and future*, i.e. connecting backward- and forward thinking)
- Wide *applicability* (e.g., to technical and social problems)

- Utilizing *divergent and convergent thinking* capabilities (i.e. associative-intuitive thinking and analytical-logical thinking)
- *Collaborative approach* to problem solving (e.g., to involve various disciplines and/or stakeholders)
- *Easily applicable* and suitable to synthesize *heterogeneous competences* of various agents and stakeholders (e.g., experts and citizens)
- Potential to be applied as single *comprehensive method* within the creative problem discovery/-solving process which (a) could, in its minimal version, already cover the whole problem solving process (from problem discovery to the generation and evaluation of innovative solutions); (b) however, in its extended version, it can provide a framework for the inclusion of other methods (e.g., the World Café might act as such a framework, which may integrate methods such as brain-writing 6-3-5 or graphic system modeling) or it can just be coupled with other methods (as outlined in Section 5).

Based on these selection criteria, Table 1 provides a condensed profile of the following six comprehensive collaborative methods in chronological order of the underlying references: (1) *Six Thinking Hats* (De Bono, 1985), (2) *Future Workshop* (Jungk and Muellert, 1987, 1997), (3) *Disney Method* (Dilts, 1994), (4) *Future Search* (Weisbord and Janoff, 1995, 2010), (5) *Open Space Technology* (Owen, 1997, 2008), and (6) *World Café* (Brown, 2001, 2002; Brown et al., 2005). Each method is outlined according to the following dimensions: author(s); designation and process orientation (i.e. linear or circular); related field of studies and potential application; the specific working phases of the problem discovery-/solving process; focus on problem discovery and the search for the “real problem(s)”; the interplay of convergent and divergent thinking modes; multilevel consideration (individual or collaboration); stakeholder management (internal and external agents); method-/methodological support for problem discovery:

- (1) *The Six Thinking Hats* by De Bono (1985): De Bono’s pragmatic approach centers on conceptual thinking (i.e. creative thinking), which can be understood as the interplay of lateral and convergent

thinking (similar to divergent and convergent thinking). Each hat embodies a different thinking mode, which can then be jointly applied (in a self-organized or pre-determined sequence) within the creative problem discovery/-solving process. The white hat stands for a neutral and objective perspective, for being concerned with facts and figures (i.e. information); the red hat for an emotional feeling or for intuitive and instinctive reactions (i.e. emotions); the black hat is associated with the "devil's advocate" by demanding the agent to act carefully and cautious (i.e. feasibility and discernment); the yellow hat stands for a sunny and positive perspective based on a logical perspective to identify potential benefits and to create harmony (i.e. optimism); the green hat is associated with fertile growth, creativity, and new ideas (i.e. creativity); and the blue hat implies an overview/managerial perspective which enables the organization of the whole process, similar to flying high up above the ground, in the blue sky, and overlooking a system (i.e. neutral observation). Within this process design, cross-pollination of perspectives and ideas among participants is supported by deliberately joining a specific working stage as expressed by either literally or metaphorically wearing a specific hat, which expresses a specific thinking mode. Although not explicitly mentioned by the author, each stage can be easily extended by the application of other problem solving methods (e.g., an Ishikawa diagram as part of the black hat stage). Hence, this repetitive process may be applied as a framework for meetings or for comprehensive workshops.

- (2) *Future Workshop* by Jungk and Muellert (1987, 1997): Jungk was one of the earliest proponents of a *process- and method guided search for future solutions* based on thoroughly investigating, discussing, and reflecting the problem and present state of a system as part of his *Future Workshop* (in German *Zukunftswerkstatt*). What makes this approach particularly remarkable in the context of this paper is that it uses creativity techniques (i.e. brainstorming) not only for the fantasy stage as the future oriented phase within a collaborative problem solving process, but already during the preceding critique phase stage (Jungk and Muellert, 1987, 1997). This implies that rational-analytical and intuitive-emotional thinking patterns, similar to two interwoven DNA strands, are jointly applied at every stage throughout the whole process (usually designed as a three-day workshop).

- (3) *Disney Method* by Dilts (1994): With Walt Disney as role-model, Dilts built on Disney's working principles and established a creative problem solving method, which uses a sequential version of role-play to generate ideas (i.e. dreamer stage), to work on measures to realize these dreams (i.e. realist stage), and to reflect and evaluate the generated ideas and the measures for their realization (i.e. critics stage). This circular and repetitive three-step problem solving process should be repeated as often as no further questions arise. Each stage can be extended by other methods (although, similar to the six thinking hats, not explicitly suggested by the author) and can take up to an hour and more, consequently the whole working process may range from several hours to two/three days.
- (4) *Future Search* by Weisbord and Janoff, (1995, 2010): Similar to the future workshop, this workshop is based on a generic agenda which encompasses the past, the present, the future, common ground, and action planning (usually designed as three-day workshop). The objective is to make systemic improvements for a system (e.g., a local community or an organization) by aiming towards a clarification of shared values, a plan for the future together with concrete goals, and an implementation strategy.
- (5) *Open Space Technology* by Owen (1997, 2008): As a significant difference to the future workshop and future search, this format starts with no initial agenda, but based on the introduction of the general purpose, the agenda is generated within this self-organizing working format. So-called 'break-out sessions' are initiated and then organized as parallel sessions of a common market place. Whereas facilitators have the overall responsibility for their sessions, the other participants move freely between the single sessions. Typically, this workshop may take between several hours to up to three days.
- (6) *World Café* by Brown (2001, 2002) and Brown et al. (2005): Within this structured conversational process, participants periodically switch subgroups for sharing knowledge and utilizing collective intelligence/creativity. Up to several hundreds of people may participate in this collaborative dialogue in which specific issues are discussed in small groups around café tables. With the exception of one person who acts as table host, the participants of the single tables will move to other tables in given

time intervals (usually determined by the moderator). This work format supports cross-pollination of perceptions and ideas, which usually take several hours (usually as a series of consecutive sessions of 15-30 minutes), but which can also act as a framework for more comprehensive workshops.

*Table 1. Compilation of Selected Comprehensive Collaborative Methods for Problem Discovery
(in chronological order of references)*

Author(s)	Designation and process orientation (linear or circular)	Field of studies & application	Phases in the problem discovery-/solving process	Focus on problem discovery and the search for "the real problem(s)"	Interplay of convergent and divergent thinking	Multilevel consideration (individual or collaboration)	Stakeholder management (internal and external agents)	Method-/Methodological support
De Bono, 1985	Six Thinking Hats; self-organized or pre-determined sequence	Creativity & innovation management	Interplay of neutral/objective perspective, emotional view, critical perspective, sunny/positive perspective, fertile/creative ideas, overlooking perspective	As part of a comprehensive problem solving process which jointly embodies different thinking modes	Yes	Collaborative, 4-12 participants	Not explicitly	Using six hats as the representations of six different thinking modes
Jungk and Muellert, 1987, 1997	Future Workshop (in German "Zukunfts-werkstatt"); linear	Future studies & community participation (e.g., democratic processes)	Preparation phase, critique phase, fantasy phase, implementation phase, follow-up phase	As basis for the other phases	Yes	Collaborative, ideally 15-25 participants (& more)	Yes (i.e. community involvement)	Future workshop as framework, extended by further methods (e.g., brainstorming)
Dilts, 1994	Disney Method; circular	Creative problem solving & Neuro-Linguistic Programming (NLP)	The dreamer, the realist, and the spoiler (or critic); sometimes the observer is added as fourth stage (in its ideal form each stage is also given a specific room)	As part of a circular and repetitive three-step problem solving process, the problem is analyzed more deeply	Yes	Collaborative, 4-12 participants	Not explicitly	The role-play like process design synthesizes three different thinking modes (which can also include architectural means)
Weisbord and Janoff, 1995, 2010	Future Search; linear	Future studies & community participation (e.g., democratic processes)	The past, the present, the future, common ground, and action planning	As basis for the other phases	Not explicitly	Collaborative, max. 40-80 in one room/ several hundreds with parallel rooms	Yes (i.e. community involvement)	Future search as framework, extended by, e.g., mind maps, creative future scenarios, common ground dialogue
Owen, 1997, 2008	Open Space Technology (OST); self-organizing	Future studies & community participation (e.g., peace negotiations)	Free and self-organized flow of participants between a plenary & small-group breakout sessions for targeting collective intelligence and creativity	Not explicitly	Not explicitly	Collaborative, from 5 to several hundreds participants (max. known is over 2,000)	Not explicitly	Flexible format for hosting group dialogues
Brown, 2001, 2002; Brown et al., 2005	World Café; flexible	Future studies	Conversational process in which participants switch sub-groups periodically for sharing knowledge & utilizing collective intelligence/creativity	Not explicitly, but as part of the overall process	Not explicitly	Facilitating collaborative dialogue (up to several hundreds of people)	Not explicitly	World Café format as a culture of dialogue & cross-pollination of perceptions and ideas

In sum, the methods described in Table 1 are particularly suited to be integrated in the problem discovery process, as they:

- Can help to get a comprehensive working process running,
- Synthesize and cross-pollinate the knowledge of various agents involved (from experts to citizens) and make use of their collaborative creative potential,
- Provide a common language,
- Can be applied in a time-efficient manner,
- Do not require specific training of participants prior to the workshop or work process (as long as the workshop leader has the appropriate skills),
- Lead to a deepened understanding of the complex real-world system and its embedded problems, and
- Help to collaboratively generate ideas, which might be useful for later solutions.

4.2 *Extended Collaborative Methods*

There is arguably a nearly endless amount of at least marginally related *methods* from various disciplines that could potentially be beneficial for problem discovery (e.g., creativity techniques, SWOT-analysis, personas, storyboarding, etc.). However, in the literature, these methods are almost exclusively dealt with as a collection of single methods rather than an interrelated set of methods, which needs to be considered as part of a comprehensive problem solving process, which includes the process of problem discovery as well. Furthermore, the primary focus of these methods, when applied, is usually not problem discovery and they are not particularly well suited to involve of a broad variety of stakeholders (including the public) when applied isolated. However, when suitable frameworks and process designs are available (e.g., see Section 3), they are powerful complementary methods as soon as they coherently fit into a common story line (see the process outline in Section 5).

Beyond the comprehensive collaborative methods outlined in Table 1, various further methods which are particularly suitable for *team formation, system analysis/-immersion, process analysis, creative discovery and concept outline, future and scenario analysis, and evaluation* are summarized in Table 2 (this is not a comprehensive, but exemplarily collection of single methods which are of particular interest

as they are applied within the working process as outlined in Section 5; the table further outlines the tasks and purpose, the disciplines, and relevant references related to the single methods). LIFO (Life Orientations Survey) is a method of particular interest for *team formation* (Katcher and Czichos, 2009), however it can also be integral part of *stakeholder analysis* (e.g., Steiner, 2008; Ackermann and Eden, 2011; Edvardsson et al., 2012). For the understanding of the system, the *metaplan technique* (Schnelle, 1979) and *mind mapping* (e.g., Buzan and Buzan, 2010) are useful basic methods, whereas the *Ishikawa diagram* (e.g., Higgins, 2006: 53-56) and *progressive abstraction* (e.g., Schlicksupp, 1999) help to deepen the understanding of the system and embedded problems. In their interplay, these methods help to gain an enhanced system understanding and provide essential knowledge for a system analysis based on methods such as *system dynamics* (Sterman, 2000) or *soft systems methodology* (Checkland, 1981, 1999). Systems analysis is further enriched by and related with stakeholder analysis (e.g., Steiner, 2008; Ackermann and Eden, 2011; Edvardsson et al., 2012), personas (e.g., Steiner, 2007b; Goodwin, 2009: 229-297), and mood boards (e.g., Goodwin, 2009: 341-345; Heufler, 2012: 53-57). Personas and mood boards are particularly helpful to capture not only functional but also emotional effects and most often make use of storytelling and storyboarding (e.g., Steiner, 2007b; Andrews et al., 2009; Goodwin, 2009; IDEO, 2011; Greenberg et al., 2012). Creativity techniques are applied for the discovery of problems as well as of ideas (e.g., Schlicksupp, 1993, 1999; Higgins, 2006; Steiner, 2007a: 267-325; IDEO, 2011; Heufler, 2012). Scenario- and trend analysis build on systems analysis and help better understand future implications (e.g., Scholz and Tietje, 2002; Goodwin, 2009; Scholz, 2011; IDEO, 2011). In order to not get lost in information, the *morphological analysis* is useful to structure problems and ideas (e.g., Ritchey, 2006; Steiner, 2007a: 321-325), extend both, and develop options of potential concepts, which can then be (pre)evaluated. Whereas prototyping (e.g., mock-ups) related to newly generated concepts is common especially in product development, a prototyping of the system and its embedded problems at the beginning of the problem discovery/-solving process is not yet typically integrated into research. However, based on the comprehensive sensual experiences provided, it helps to improve the system- and problem understanding as well (e.g., Steiner, 2007b; IDEO, 2011; Heufler, 2012). For benchmarking and

strategic orientation, the innovation radar (Sawhney et al., 2006) and the SWOT analysis (e.g., Wehrich, 1982; Helms and Nixon, 2010) can be supportive.

Based on the arguments provided in the previous sections, specific methods for problem identification and problem analysis benefit from a recurrent collaborative working process, which makes use of analytical-logical and associative-intuitive thinking of all its problem solvers. For example, it is the Ishikawa diagram or the progressive abstraction in interplay with other methods (e.g., creativity techniques) embedded in an iterative working process, and not the single method alone, which enables the successful identification of the “real problems” as important basis for the generation of innovation.

Table 2. Compilation of Extended Collaborative Methods (see related methods and tasks in Table 3)

Method	Tasks in working process	Purpose within the working process	Disciplines	Reference
LIFO (Life Orientations Survey)	Team formation/management	Discovering and using the problem solvers' strengths as a means for team management & enhanced communication/learning	Personal development	Katcher and Czichos, 2009 (originated by Atkins and Katcher in the 1970s)
Metaplan technique	Understanding the system	Visualizing arguments & ideas to support collaborative interaction (with post-its & moderation, & design)	Communication, moderation, & design	Schnelle, 1979
Mind mapping (similar to concept maps, knowledge integration maps, & topic maps)	Understanding the system & structuring information	Visualizing information & enabling associations, stimulating the generation of ideas, and supporting creativity	Education, learning, & design	e.g., Buzan and Buzan, 2010 (originated by Buzan in the 1960s)
Ishikawa diagram (cause-effect diagram)	Understanding the system & establishing a basis for creative associations	Understanding multiple causes related to an overall effect (highly structured visualization)	Quality management	e.g., Higgins, 2006: 53-56 (originated by Ishikawa in the 1960s)
Progressive abstraction	Understanding the system & establishing a basis for creative associations	Specifying a problem by successively changing ones perspective (problem-variation) to provide a new setting for idea generation	Creative problem solving	e.g., Schlicksupp, 1999 (originated by Geschka)
Systems analysis: e.g., (a) System Dynamics (b) Soft Systems Methodology (SSM)	Understanding the system & outlining future concepts	Tackling complex real-world systems (e.g., conceptual/graphical but also quantitative models) to understand interdependencies within a system and with its environment	Systems thinking/- modeling	(a) Serman, 2000 (b) Checkland, 1981, 1999
Stakeholder analysis	Understanding stakeholders' preferences & plan their potential	Understanding the preferences of stakeholder groups (also as basis for stakeholder involvement)	Innovation management & industrial design	e.g., Steiner, 2008; Ackermann and Eden, 2011; Edvardsson et al.,
Personas (based on storytelling and storyboarding)	Understanding users: functions & emotions	Supporting user-centered process analysis to better comprehend their underlying mental models (i.e. user archetypes) and functional as well as emotional perceptions	Industrial design	e.g., Steiner, 2007b; Goodwin, 2009: 229-297
Mood boards	Understanding users & concept outline: emotions	Determining the moods, values, & attributes of a target group (i.e. a collage of images, samples of objects, and text)	Industrial design	e.g., Goodwin, 2009: 341-345; Heufler, 2012: 53-57
Storytelling & storyboarding (either photo- or sketch-based)	Understanding users, concept outline, scenario analysis, & personas	Capturing the dynamics of a process and making a concept more concrete (e.g., conceptual comics)	Cinematic & industrial design	e.g., Steiner, 2007b; Andrews et al., 2009; Goodwin, 2009; IDEO, 2011; Greenberg et al.,
Creativity techniques: (a) Brainstorming-based (e.g., brainstorming, 6-3-5 brainwriting, brainpooling, collective notebook) (b) Analogy-based (e.g., synectics, bionics)	Creative discovery (of problems and ideas)	Generating creative ideas and potential solutions as input for options (i.e. concepts)	Innovation management & industrial design	e.g., Schlicksupp, 1993, 1999; Higgins, 2006; Steiner, 2007a: 267-325; IDEO, 2011; Heufler, 2012
Scenario- & trend analysis (e.g., with storyboards and personas): (a) Context scenarios (b) User scenarios	Future implications (i.e. scenarios)	Attempting to comprehend future patterns of development, either related to the system (i.e. user scenarios) or its environment (i.e. context scenarios)	Systems thinking/- modeling, industrial design, & innovation- /strategic	e.g., Scholz and Tietje, 2002; Goodwin, 2009; Scholz, 2011; IDEO, 2011
Morphological analysis	Problem structuring, creative discovery, concept outline, & evaluation/(pre)selection	Generating options by structuring ideas/potential solutions along relevant system parameters & providing a basis for evaluation/(pre)selection	Engineering, astrophysics, & innovation management	e.g., Ritchey, 2006; Steiner, 2007a: 321-325 (originated by Zwicky in the 1940s)
System- & concept prototyping (mock-ups)	Problem understanding, concept outline, & realization (incl. evaluation)	Deepening the understanding of a problem & the related concept (e.g., product, service, or process) and its applicability by enabling a comprehensive sensual experience (e.g., visual, haptical) and by acquiring feedback from users	Industrial design & software/systems engineering	e.g., Steiner, 2007b; IDEO, 2011; Heufler, 2012
Innovation radar	Evaluation/benchmarking & preselection of alternatives (but also useful for competitor analysis)	As part of a so-called 360-degree view, the focus is on four key dimensions: (1) the offerings of a concept/company, (2) the customers it serves, (3) the processes it employs, and (4) the points of presence it uses	Innovation management	Sawhney et al., 2006
SWOT analysis	System analysis & strategic outline	Developing feasible strategic options based on a structured analysis of a concept's internal factors (i.e. strengths and weaknesses) and external factors (i.e. opportunities and threats)	Strategic-/ innovation management	e.g., Weihrich, 1982; Helms and Nixon, 2010 (originated by Humphrey in the 1960)

The methods introduced in this section provide the basis for the set of convoluted methods for applied creative problem discovery as a collaborative approach presented in Section 5. As outlined in the next sections, the comprehensive collaborative methods of Table 1 are useful for getting the real-world problem solving process started by “getting people on board” in that they help to provide a supportive and trustful working climate. Further, they are supportive for inter- and transdisciplinary collaboration (which includes stakeholder involvement) and allow cross-pollination of perspectives and ideas based on a first deepened insight into the initial problems. The extended methods of Table 2 complement the comprehensive methods of Table 1 as they are applied together within an iterative working process.

5. How to organize a method-guided problem discovery process?

If I had an hour to solve a problem and my life depended on the solution, I would spend the first fifty-five minutes determining the proper question to ask, for once I know the proper question, I could solve the problem in less than five minutes.

(Einstein, 1931: 97)

Both for incremental innovations, but in particular for radical innovation (which is closely associated with a simultaneous change in social patterns), it is essential to be acutely sensitive to potential problems within the underlying system (e.g., product, process, service, or business model) and meta-systems (e.g., organization, cluster, or region), as well as its interrelated environment.

My real-life experience from working with participants of numerous innovation and future development workshops and projects, which I conducted over the past 15 years, made me realize how difficult it can be for problem solvers and professionals to see beyond an immediate system and immediate problems (which might be only symptomatic). I propose that a method-based search for “real problems” can be tremendously helpful when attempting to generate meaningful innovations during a

creative problem solving and innovation process. Based on the Planetary Model, collaborative problem discovery and the associated search for potential solutions are interwoven parts of a common working process and can be supported by *convoluted methods*. These methods stem from various disciplines and are aimed to comprehensively support analytical-logical and associative-intuitive thinking patterns as part of the overall creative problem solving process (see the comprehensive outline in Section 4).

The Planetary Model of Collaborative Creativity (PMCC) has previously been introduced to a broad audience of academics, practitioners, and students in the field of innovation. In real-world applications, together with the logbook-based sequential working procedure described in Figure 3, it has served as a framework for inter- and transdisciplinary collaborative problem solving processes both at the organizational and the policy level. However, in this paper, for the first time, the further refined Planetary Model is presented as part of a comprehensive method-based working process: based on two exemplary real-world applications, I will introduce how various methods can be applied within this framework. While this framework is aimed at providing orientation, it does not provide a blueprint for process design and applied methods. It can nevertheless be used as a process outline which can serve as a role model, considering that the working process and applied methods need to be re-designed and adapted according to the specific requirements of any given project.

The following workshop design, in its key characteristics, served as a framework for two particular cases of innovation development: a “futures project” with BMW (which took place between March and June 2010) and, in an advanced version, a project with Kaercher (between March and June 2013). Both projects followed an open innovation (e.g., Chesbrough, 2003, 2006) and open creativity (e.g., Steiner, 2009, 2011) approach as part of a collaboration effort between each company and the School of Industrial Design in Graz, Austria. In both cases, besides problem solvers from each company and the school, additional external agents (e.g., non-customers, customers, potential customers, experts), were involved during specific working phases. Of note, not only the composition of the problem solving team, but also the role of a specific problem solver could change during single (sub)phases of the problem solving process (e.g., in one phase a superior member of the company might be provider of relevant information


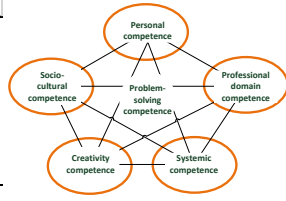
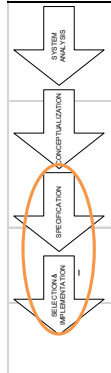
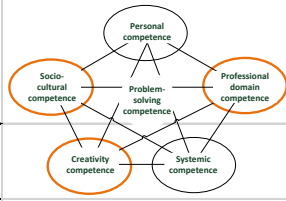

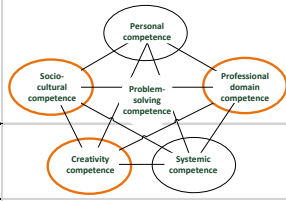
within the working process, but later their role might switch to an idea sponsor by working together with other problem solvers and applying a certain creativity technique).

In the following, I describe the core phase of initial product development, - the *innovation workshop*. The primary aim of this workshop is to set off an innovation process, which may initially be centered around topics only loosely related to the actual product, and to provide orientation throughout the overall product development process: (1.) by providing an understanding of the relevant system and its environment; (2.) by identifying “real” problems as the core ingredients of successful innovation; (3.) by providing a core portfolio of innovation concepts; (4.) by outlining the storylines of those concepts and by (pre)evaluating them; (5.) by embedding these concepts and storylines within the system and its relevant environment; (6.) by drawing future development paths of the environment; and (7.) by interrelating selected concepts and storylines within these potential future scenarios. As said above, the primary objective of this initial core phase is simply to have the development process on the right track when working on the functional, technical, and emotional specifications, which should ultimately lead to implementable innovation in accordance with future users’ needs. The problem discovery/-solving methods need to be applied in a manner that allows *convergent and divergent thinking* of the individuals of the collaborative entity to synergistically enhance each other (see Table 3). For the success of the innovation workshop, the workshop location is particularly important as a *shared space*, which should provide a pleasant atmosphere in support of the collaborative working process.

Structurally, the *innovation workshop*, which I briefly describe in the following, is divided according to the sequential working procedure introduced in Figure 3, encompassing system analysis, conceptualization, specification, and selection & implementation. Besides outlining each single working stage, Figure 3 further relates the specific focus within the problem discovery/-solving process (i.e. planets to be visited) to the specific working steps & tasks to be accomplished as well as related guiding questions and objectives (i.e. explains what the goal of each specific task is and provides guidance for the problem solvers), the methods to be applied, and the required competences.

Table 3. "The Voyage" – An Example of a Method-Based Innovation Workshop

Working Stage	Planets to be visited (What is the focus within the problem discovery/-solving process?)	Working Steps & Tasks (in sequential order)	"Guiding questions" + Objectives (What is the task about?)	Methods	Essential Competences
		Introduction & project outline (incl. contracting)	What is this voyage all about?	Input & discussion	
		Company's Input Part I: Company & innovation strategy	Understanding the company	Input & discussion	
	In the following only the below schematic of the PMCC will be used!	Company's Input Part II: Briefing	Understanding the company & its future orientation	Input & discussion	
		Innovation & innovation processes/-systems	Understanding innovation, its generation, & implications on various innovation systems	Input & discussion	
		Work environment	How to establish a creative work environment? Appropriate locations for single working stages?	Choice & design of the working environment	
		Team formation/-management I	How to build a competent team? Which stakeholders can be involved (+ in which phase)?	e.g., LIFO	
		System immersion I: Search for great challenges (=table topics for World Cafe)	Understanding the system: What are potential meta-fields of interest? (based on an exploratory spirit) -System boundaries? -System objectives? -System structure?	-Metaplan-technique -Good/bad practices -System model (draft) -System prototyping	
		Stakeholder analysis I	Who are the stakeholders and how are they affected? -Directly affected? -Indirectly affected?	-Stakeholder map	
		System immersion II: Looking behind symptoms	What are problems behind the problem(s)? (an initial try) (a.) 3 "cool" problems (red post-its) (b.) Potential "cool" ideas (green post-its) (c.) Open question(s) (blue post-its)	-World Cafe -Metaplan-technique -Ishikawa -Plenum: Presentations (captured on film)	
		Stakeholder analysis II	Understanding of: a.) Key-stakeholders? b.) Preferences/objectives? c.) How are they affected?	-Mind mapping -Stakeholder matrix	
		System immersion III: Process analysis	Understanding of the process & related stakeholder implications	-Storyboarding -Storytelling -Observations -(Self-)Experiments	
		Team formation/-management II	Creative internal & external problem solving agents?	Screening for agents	
		Creative discovery I	Creative ideas/solutions for 1-3 "real" problem(s)? (incl. creatively searching for problems)	-Brainwriting 6-3-5 -Brain Pooling -Synectics	
		Understanding the users: functions & emotions	Outlining the processes related to the "real" problem(s) What is the storyline behind? (a.) One "feasible" storyline (b.) One "highly visionary" storyline	-Process mapping Observations -(Self-)Experiments -Personas -Mood boards	
		Research I	Research on 3-4 ideas/issues of "system-process-problem" Research objectives?	-"Market place" of information -Secondary research -Information platform -Mood boards -Storyboarding	

		Creative discovery II Deepen & further extend 3-4 single ideas/issues of the process mapping or of the 6-3-5	-Brainstorming -6 thinking hats -Walt Disney	
		Research II Research on 3-4 ideas/issues of "system-process-problem" Research objectives?	-Secondary research -Primary research -Info-platform -"Market place" -Mood boards -Storyboarding -Foto-diaries	
		Concept outline I (i.e. draft concepts) Core dimensions of a concept? Potential ideas/solutions? Coherents alternatives?	-Morphological analysis -Clustering of ideas -Personas -Storyboarding	
		Innovation & sustainability Understanding the interdependencies of innovation, destruction, & sustainability	-Input & discussion -Best practices	
		Future implications I: Scenario analysis What are the relevant environmental dimensions (e.g., technology, socio-cultural trends)? Consistent development paths of these dimensions? (e.g., 2 scenarios)	-System model -Trend analysis -Scenario analysis (qualitative or quantitative)	
		System immersion IV: Reframing Rethinking the problem(s)? Rethinking stakeholders' objectives/preferences? Update of ideas?	-Problem reframing -Analogy-based creativity technique (e.g., bionics) -Synthesis of lessons learnt	
		Concept outline II (i.e. adaptation of draft concepts) Rethinking the draft concepts? Pool of consistent & feasible concepts	-Concept reframing (incl. storyline)	
		Future implications II: Scenario analysis (i.e. match of concept & future environment) Do draft concepts (product storylines) fit into future environmental scenarios?	-System model -Scenario analysis -Personas -Mood boards	
		Evaluation/ benchmarking & preselection of alternatives Dimensions of success? Stakeholder-specific evaluations	-Innovation radar -Multi-criteria decision making	
		Immersion into 2-3 alternatives Detailed exploration of preselected concepts	-Morphological analysis -Feasibility analysis -Rapid prototyping -Market analysis	
		Draft of potential market strategies How to approach the market?	-Creativity techniques -SWOT -Storyboarding	
		Realization of 1(-2) concepts Evaluation, selection of concept of realization, & setting the course for implementation	-Prototyping -Business plan	

As pointed out in Table 3, the emphasis of this voyage towards innovation is on the first three working stages; selection and implementation are only marginally considered.

The initial guiding question during the first working stage *System Analysis*, which builds the foundation for the entire innovation project is: What is the purpose of this voyage? This is the time when a combination of purpose, motivation, and a joyful outlook can provide powerful motivation to

collectively set off on the gratifying – yet trying – path to innovation. A thorough understanding of the system and its relevant environment is essential in the search for the real problem(s). However, because people usually associate an innovation workshop with generating ideas and developing real, creative solutions, it can be difficult to convince people of the necessity to first conduct a system analysis. Nonetheless, the more time and effort one devotes to this task, the higher the quality of later solutions tends to be. Also crucial during this first working stage is the creation of a supportive work environment and team formation/management (see outline in Table 3). *System Immersion*, as the next working step, is aimed at acquiring an enhanced understanding of the overall system and its environment in which the iteratively reframed problem is embedded. Therefore, guiding questions now become increasingly specific and varied methods are now applied to strengthen the dynamic interplay of divergent and convergent thinking. Just like other working steps & tasks, *System Immersion* follows an iterative working process. For example, *System Immersion I* is followed by *Stakeholder Analysis I*, followed by *System Immersion II* and *Stakeholder Analysis II* etc. This procedure can be repeated as many times as needed and is helpful in avoiding rigid thinking paradigms and processes which could constrain the ability to gain new perspectives and limit the flow of thoughts. My own year-long experience led me to believe that a thorough system immersion is perhaps the most essential pre-condition in the search for the real problem(s) and consequently for the innovation output.

The second working stage *Conceptualization*, initially focuses on developing ideas and drafting potential solutions as part of the extended task *Creative Divergence*, which similarly occurs in an iterative manner during the whole working process. As another task of *Conceptualization*, future scenarios of system-relevant environments as well as of the respective system itself (e.g., an enterprise, a product portfolio, or single products) are delineated and constructive and/or destructive effects as well as sustainability implications of the system are analyzed. Within this working stage, process mapping and intensified secondary and primary research efforts complement the creative search for solutions. Because these working steps help the problem solvers to think outside of the box, they will now intentionally be redirected to a repeat of the task *System Immersion*, which, because of the problem solvers' now

transformed mindset, will ultimately lead to a reframing of the problem. An initial set of a number of rough concepts is developed during this working stage, which are then constantly reassessed, reframed, and adjusted in order to match future scenarios of the system-relevant environment.

The third and fourth working stages, *Specification*, and *Selection and Implementation*, are both aimed at further narrowing down the number of concepts, using a set of pre-specified selection criteria. Methods, which accompany these processes are, for example, gradually improved mock-ups, rapid prototyping, business plan guided market investigations, and experimental investigations. These methods are primarily aimed at meeting consumers' desires, but must also fit the business client's strategy.

Along the four working stages, – although with different focus – comprehensive problem solving competences are needed, which comprise personal, professional domain, systemic, creativity, and sociocultural competences. This working stage-specific application of methods within a comprehensive process of problem discovery and problem solving can be considered as a form of *design thinking*, especially when this term is aimed to describe a process which provides substantial guidance beyond single methods borrowed from design studies which then tend to be superficially applied (in accordance with today's use of the term design thinking).

6. Concluding remarks

Problem discovery is not a preliminary stage of idea generation (i.e. generation of alternatives); rather, it is part of an iterative working process with recurring working steps during which a variety of methods are applied (sometimes in a repetitive manner). Creativity – if it should lead to meaningful innovation – is essential already during the search for the underlying “real” problems and not only during the search for solutions. In this paper, the power of method-guided problem discovery for innovation generation has been highlighted, in support of a collaborative approach. It showed that collaboration can

be a powerful vehicle in dealing with complex systems, since such systems, in order to be comprehensively understood (e.g., regarding their sociocultural, economic, financial, ecological, political, legal, institutional, infrastructural, and technological implications), depend on different scientific disciplines. Furthermore, they increasingly call for a joint effort of science/research and society (e.g., citizen-driven innovation) so that their specific knowledge, perspectives, values, and preferences can also be integrated.

The *process outline* introduced in Section 5 showed that problem discovery and system analysis can not necessarily be considered as a working phase prior to idea generation; rather it suggests that problem discovery ought to be viewed as part of a circular and interdependent problem solving system, since recurring patterns of convergent and divergent thinking modes enhance a successful collaborative search for the “real problems” respectively the raw diamonds of innovation. The “real problems” as the raw diamonds of innovation become the *link between the past, the present, and the future*; they have the potential to provide a more sophisticated basis for future/scenario thinking and strategic foresight.

A future challenge will be to (1.) better understand the influence of individual *mental models* on collaborative behavioral patterns and to (2.) develop and emphasize appropriate *educational measures* to provide the *competences* needed, if one wants to successfully engage in collaborative multilevel problem solving processes which involve different scientific disciplines and also stakeholders of various levels of society. To gain access to, and further develop their systems thinking, creativity, and collaborative capabilities become a central theme. Therefore, the *role of social media and of new forms of information and communication technology in knowledge integration (and generation)* is of high interest both from a scientific as well as from a practical perspective. In the Beatle’s words, following this “long and winding road”, may finally, “lead to your door”, as the door to innovation.

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