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AGILE INNOVATIVE IMPULSES IN PRODUCT GENERATION ENGINEERING: CREATIVITY BY INTENTIONAL FORGETTING

J. Heimicke, N. Reiß, A. Albers, B. Walter, J. Breitschuh, S. Knoche, N. Bursac

IPEK – Institute of Product Engineering,
Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Abstract: Innovations – according to their definition - have always guaranteed market success for companies. As a result of a large number of dynamic boundary conditions in the markets, innovation processes are changing as well. Thus, agile development processes are increasingly finding their way into hardware development in order to counteract the high dynamic of the development environment. However, creativity remains an important key to innovation. Nevertheless, there is currently a lack of efficient creativity methods that stimulate innovative impulses purposefully based on the PGE - Product Generation Engineering. This article introduces a creativity method that expands the stimulus imaging method and stimulates innovative impulses in a purposeful manner and optimizes their maturity for downstream processes. The method has been validated in a scientific study in various Live-Labs derived from the ASD – Agile Systems Design.

Keywords: *agile design methods, innovative impulses, design creativity*

1. Motivation

Theories of economic development are very dynamic. They deal with the consequences of processes from the past and include the generation and influence of novelty on economic evolution (Boschma & Martin, 2010). Schumpeter considers this transformation to be a consequence of innovation driven by companies. In this context, he distinguishes innovation from invention through actual and long-term market success of the invention (Schumpeter, 1939). However, innovations themselves do not serve as an end. Moreover, innovations arise from a previously identified market demand situation. This is defined from the customer and provider perspective. This requirement situation, which has a solution-neutral character, is described in a product profile alongside other factors such as the subsequent customer benefit, addressed target groups, possible use cases and potential sales markets. A product profile (short: profile) is to be understood as an initial product description (Albers et al., 2017). It is a model of a bundle of benefits that makes the intended provider, customer and user benefits of this bundle accessible for validation and explicitly specifies the solution area for the design of a product generation. However, identifying a suitable profile is by no means intuitive or trivial. It requires an understanding of the product development process as a problem-solving process, within which the profile describes the state of the problem that is solved by a suitable invention (Albers et al., 2016). It is also necessary to understand the developer at the centre of this problem-solving process and to support him through a

structured problem-solving methodology across the entire innovation process in a situation-oriented and demand-oriented manner (Reiß et al., 2016). The generation of innovations to satisfy needs and ensure economic success is therefore the goal of commercial enterprises in order to maintain their competitiveness in the market against competitors. Due to increasingly dynamic changes in the market environment, which can be attributed among other things to trends in individualization and connectivity, companies are acting increasingly agile in the innovation process to ensure an increase in flexibility (Boehm & Turner, 2005). The goals and approaches of the development, based on agile processes are, among other things, a continuous increase in the value of the development result, iterative procedures and the avoidance of supposed waste in planning-driven processes (Salah et al., 2014). Innovations in the agile process, which in turn lead to products on the market, are not created from scratch on a white sheet of paper (Albers et al., 2014). Rather, new product generations are being developed on the basis of reference products and previous product generations, which is called PGE - Product Generation Engineering (Albers et al., 2014; Albers, et al., 2017). It is possible that innovations may arise from a so-called Eureka effect, resulting from the development team's comprehensive examination of the development task and an extensive analysis of existing reference products. Thus, a developer in the innovation process is able to translate creative moments into technical solutions. These moments are mostly due to so-called innovation impulses, which are understood as "context-related stimuli with the potential of a successful realization as innovation" (Albers et al., 2013). Purposeful innovation impulses, which have a stimulating effect on the developer's creativity as environmental influences (Amabile et al., 1996), can thus be provoked in creative process phases. Creativity methods that promote context-specific, targeted stimulation of innovation impulses do not exist. Companies face different challenges in practice during the innovation process. Particularly with regard to agile development processes, it is necessary to deal with the targeted stimulation of innovation impulses, as these processes are usually characterized by a tight time limit and are characterized by the rapid completion of tasks. This often means that there is no room for creativity and no time for methodical preparation of creativity methods. In addition, currently no criteria, which describe a PGE-compliant creativity method, exist. For this reason, methodical, fast and flexible solutions are needed, which can often be reused without losing the quality of the generated innovation impulses. The aim of this article is to analyse the current and future requirements and boundary conditions with regard to creative phases in agile PGE processes and to present a structured definition of a methodological profile, an intuitive, quickly adaptable and target-oriented creativity method. In addition, the approach is extensively validated in the course of the work.

2. State of the Art

2.1. ASD – Agile Systems Design in the PGE – Product Generation Engineering

The approach of PGE, according to Albers, closes the gap between the illustration of the high diversity of the respective parts, which have to be newly developed, in product development projects, which could not be completely described by the existing theories like the design methodology according to Pahl (Pahl & Beitz, 2013) and the innovation management according to Henderson and Clark (Henderson & Clark, 1990). Thus, PGE can be understood as an extension of these theories. It is used to develop new product generations, usually on the basis of existing reference products or reference solutions. In addition, the development of new product generations is carried out through a systematic and purposive combination of the activities of *Carryover Variation* (CV), *Embodiment Variation* (EV) and *Principle Variation* (PV). EV and PV combined represent the respective parts, which have to be newly developed in the new product generation. In the course of the introduction of a sufficient number of differing features in new product generations in order to achieve an unique position in the market, the development risk can be estimated by identifying the range of variation. (Albers et al., 2017). For some time, agile processes have also been applied in the area of developing new product generations in hardware industries (Boehm & Turner, 2005). Instead of the Traditional Waterfall Model (Royce, 1987), i.e. an orderly sequence of activities, agile processes and methods such as *Design Thinking*, *Scrum* or the *ASD - Agile Systems Design* are used. These approaches do not define a determined sequence of activities, but allow iterative and simultaneous activities. In addition, agile approaches are human-centred and based on a deep un-

derstanding of demand-situations (Plattner et al., 2011). An early and continuous validation by the customer of first prototypes, whose level of maturity is continuously increased throughout the process, is the core of agile processes. While *Design Thinking* is particularly suitable for the systematic solution of complex problems (Dym et al., 2005) and *Scrum* supports agile project management (Schwaber, 2004), *ASD* is geared towards supporting the entire development process. Up to 6 phases form a framework (Albers et al., 2017), within which design methods are recommended according to the situation and demand of the developers (Albers et al., 2015). In **Figure 1.** the *ASD* approach is presented.

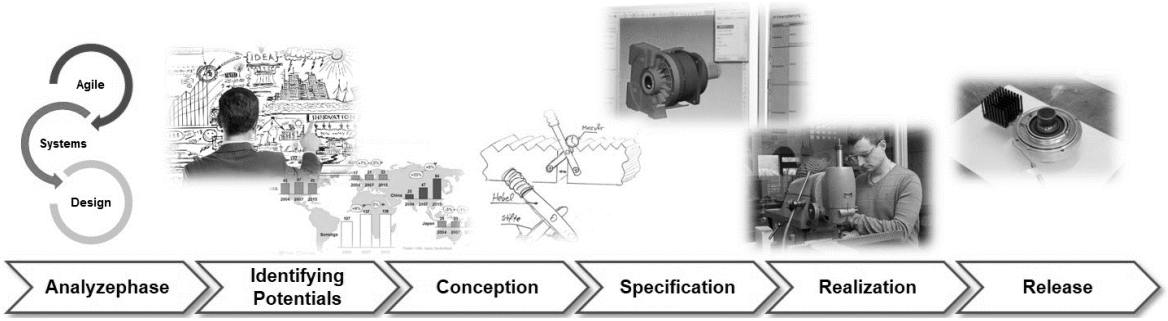

Figure 1. The ASD – Agile Systems Design Approach

An intensive examination of the entire context during the *Analyzephase*, leads to a systematic identification of profiles in the phase of *Identifying Potentials*. During the four subsequent phases, ideas, concepts and prototypes, whose functional scope is continuously increased over the phases, are developed.

2.2. Creativity and innovative impulses – the way to innovation

For companies operating in the economic sector, innovation is the core of their strategies for profitable growth and gaining market share (Hamel, 1998). Product innovation is essential for corporate innovation. The core of the product innovation is, in turn, the creative design (Li et al., 2007), whereby creativity plays a superordinate role in the innovation process. The ability of *being creative* is strongly dependent on the cognitive abilities of each individual (Amabile, 1988). Although current cognitive-psychological theories pursue the thesis that creativity is based in particular on convergent-logical thinking operations, these theories also attach considerable importance to intuitive and imaginative processes. Metaphors and analogies are regarded as essential impulses for creative processes (Preiser, 2006). If these impulses result in an innovation, they are called *innovative impulses*. According to ALBERS, innovative impulses are defined as “context-related stimuli with the potential for successful implementation as innovation”. They can arise from very different sources; for example, from external sources, i.e. from outside the company or from internal sources, i.e. innovation impulses (Albers et al., 2013). These impulses can be stimulated by various methods of creativity (Howard et al., 2011). Methods describe a goal-oriented procedure. They have a descriptive and instructional character and should assist the user in achieving a particular goal. Thus, Lindemann defines the term "method" as the description of a rule-based and planned action to perform certain activities according to their specification (Lindemann, 2005). To stimulate creativity, it is possible to use so-called solution-finding methods. Thus, averagely creative people can generate original and innovative ideas, which makes it possible to make better use of the existing creativity potential. By analysing more than 400 development projects from practice, Graner showed that an integrated method application can strongly support the engineer in the creative process (Graner, 2012). For example, intuitive methods such as brainstorming, brainwriting, the 6-3-5 method or the stimulus picture method promote thought associations in the search for new ideas (Lindemann, 2005). The high number of solutions results in a rational and objective selection of the best ideas. Furthermore, the use of these methods increases the likelihood of obtaining good solutions compared to a procedure without a method (Deigendesch, 2009). Basically, it is thus possible to solve problems in an intuitive way, or by means of a systematic, analytical approach (Geschka & Lantelme, 2005). However, methods are insufficiently integrated into the daily development practice of agile teams and are rarely fully exploited in their potential. Recent, rarely accepted research on this topic comes to the conclusion that science is often too far from reality (Bavendiek et al., 2014; Reiß et al., 2016). In creative activities in particular, the individual needs of the engineer as well as the individual patterns of agile

work and thought are only inadequately considered (Lubart, 2001). Studies show that in practice only a small number of methods are used (Albers et al., 2014).

3. Research needs, research methodology and research questions

Innovations and the associated creative processes remain the focus of entrepreneurial, profitable activities and strategies. However, the conditions for creative processes are changing due to the high dynamics of the markets. The requirements concerning the result of the innovation process do not change - innovations still have to show different characteristics compared to product generations already on the market, satisfy customer demands and be successful on the market. The innovation process, on the other hand, with the aim of stimulating innovative impulses, must fulfil new requirements. Effective methods of creativity must stimulate purposive impulses for future trends and scenarios. The described method is developed by answering the following research questions:

- What are the requirements for a method of creativity that supports the developer in the innovation process consistent with agile PGE? (Research question 1 = RQ1)
- How should a method be designed that supports the generation of innovative impulses (product ideas, ideas for product profiles) on the basis of existing reference systems? (RQ2)
- Does the inclusion of reference products increase the generation of innovation impulses compared to existing methods of creativity in terms of quantity, quality and agility? (RQ3)

In the course of the Live-Lab (Walter et al., 2016) *AIL – Agile Innovation Lab* requirements of an agile method of creativity in accordance with agile PGE are identified (answer to RQ1). Based on this the method is developed and the use of the method is described, which answers RQ2. Then the method is validated and adapted in the early - not yet final - version in the Live-Lab *ProVIL – Product development in a virtual Idea lab* (Albers et al., 2016), which leads to the answer to RQ3.

4. Results

4.1. Profile of a suitable agile method of creativity

In order to meet the above-mentioned criteria, a new approach is needed, which supports the developer in the outlined field of tension between agility and creativity. As a reference method, the *Random Picture Technique* (Brunner, 2008) was chosen. This very simple creative technique encourages creative thinking and brainstorming. You learn to see things from a completely new perspective. The *Random Picture Technique* aims to set a creative process in motion by confronting images that are not connected with the creative question. The method consists of three steps:

1. View the picture.
2. Analysing the image according to important aspects, functions, design features, feelings, spontaneous thoughts, experiences, memories.
3. Transferring the answers to creative questions

The arbitrary selection of images does not always guarantee that creativity sessions will be conducted in a targeted manner. In addition, existing reference products or the previous generation is often ignored. This excess of free creativity leads to increased iteration cycles and extended development times, especially in agile development processes. Particularly in more advanced phases; hence, guided creativity is necessary. Therefore, a method that supports the creative process based on reference products is needed. Especially in an agile environment, the method must be feasible without any major preparation and has to be self-moderated by the development team. In order to achieve the highest possible and targeted accumulation, impulses from different areas should be combined. These could originate, among others, from the domains: predecessor generation, reference products, trends and scenarios. In order to achieve the greatest possible acceptance, the method must be designed to be easily accessible and entertaining.

4.2. InnoBandit - Increase creativity in agile PGE processes

Based on the presented profile and the PGE - approach, a new method of creativity for agile development processes was created. The *InnoBandit* (**Figure 2.**) extends the *Random Picture Technique* to three parallel appearing images that are supposed to prompt an impulse. The *InnoBandit* is used especially in the

early and creative phases of the PGE-process, as it offers the greatest creative freedom. Graphically, it is based on a slot machine as known from Casinos. The *InnoBandit* is divided into the areas *task definition*, *impulse images* and *result-space*. The task in the form of the current product generation can be found in the upper left corner of the screen and consists of an illustration of the current product generation, the G_{n-1}. This ensures that the topic and the product to be developed (G_n) remain permanently in memory and that profiles or ideas do not deviate, but remain focused. The second field is the main area, where the *impulse images* are located. These are divided into three categories: *Megatrend*, *Microtrend* and *Reference Product*. The first category, the *Megatrend*, describes "global as well as profound and sustainable social, economic and technological changes that are slowly unfolding, shaping the long term and shaping the future" (Fontius, 2014). This category and the associated long-term security with regard to changes supports a more robust and future-proofed generation of profiles and ideas. The second category, *Microtrend*, includes cross-industrial aspects like new technologies or service innovations. *Microtrends* broaden the horizons of generated profiles and ideas to include existing and functioning but new and unused ideas and technologies. This ensures an increased maturity of the method results. The third category shows *Reference Products* that depict current technologies from the specific sector. This leads to generating the impulses through a purposive use of the PGE approach, based on existing reference products. By showing a reference product, the diversity of the new components, which are to be developed, is reduced and thus the developing risk can be lowered. The visual stimuli of the three images are intended to stimulate an association that leads to an innovative impulse. In contrast to the *Random Picture Technique*, the images shown are assigned to fixed categories, which gives a focus without restricting creativity too much. The visual stimuli of the three images are intended to each address a different context, which stimulates different associations that lead to an innovative impulse. In the context of *intentional forgetting* - the leaving behind of entrenched thought processes - the developer takes all stimulated associations and explicates an innovation impulse, that encapsulates as many associations as possible. In contrast to the *stimulus picture method*, the images shown are assigned to fixed categories, which leads to guided creativity by giving a focus without restricting creativity too much. The third area of the *InnoBandit* contains the result field (Profile / Idea for generation G_n). Here, one or more profiles or ideas are documented for each triplet of impulse images while the method is being executed.

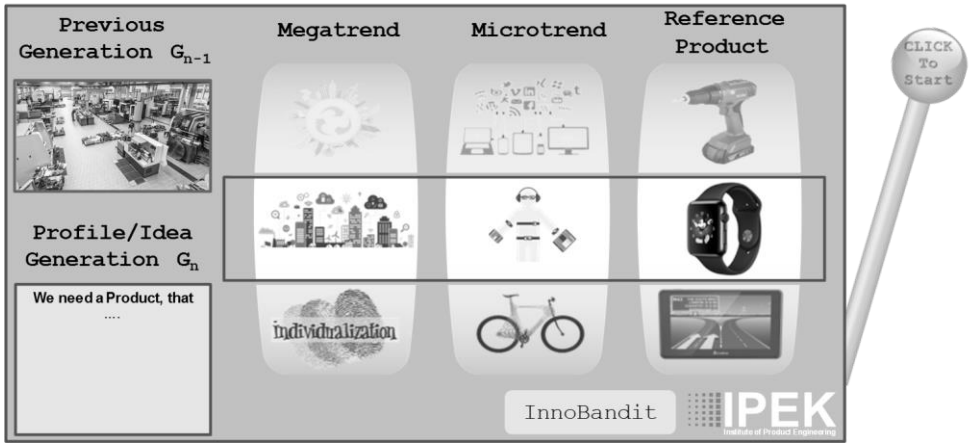

Figure 2. Graphical representation of the *InnoBandit* method

In order to prepare the *InnoBandit* for specific projects' creativity sessions, two steps have to be taken. The categories *Megatrend* and *Microtrend* have to be checked for their topicality and, if necessary, individual *impulse images* have to be exchanged. In addition, the category *Reference Product* has to be adapted to the particular industrial sector. Each category contains several *impulse images*. The category *Megatrend* contains 12 images. For the categories *Microtrend* and *Reference Product* about ten images should be chosen. This results in a combination of 1200 impulse triples, which nearly excludes the possibility of a repetition of a triple. If the lever on the right side is pulled, an *impulse image* from each category is randomly selected and displayed. Now it is the task of the developer to generate innovative impulses based on the associations triggered by the *impulse images* and to write them into the result field.

5. Evaluation in the Live-Labs *AIL* and *ProVIL*

The agile creativity method *InnoBandit* has been validated within two projects: Live-Lab *ProVIL* and Live-Lab *AIL*. These Live-Labs are derived from the *ASD* approach and are conducted annually. A Live-Lab is a research environment that can be classified between laboratory studies and field studies - the results are neither too specific and therefore not transferable to other problems, which is often the problem with field studies, nor too generic with few practical results, as is often the case with laboratory studies (Albers et al., 2016). In *AIL2017*, four students developed innovative product concepts and prototypes in cooperation with the company Trumpf. The *AIL* process passes through all six phases of the *ASD* approach. The *InnoBandit* was already used to identify profiles in the phase *Identifying Potentials*. Out of a total of approximately 100 profile claims, 50 originated from the *InnoBandit*. The remaining were generated during other methods (for example persona method, brainstorming). The profile that was finally chosen also resulted from the *InnoBandit*. The *InnoBandit* was also used in the subsequent phases to generate creative and purposive ideas. The study was able to show that the *InnoBandit* promotes creative ways of thinking. The Live-Lab *ProVIL* was also derived from the *ASD* approach in analogy to *AIL*. However, *ProVIL* only goes through the first four phases of *ASD*. In 2017, 49 students of the Master's program participated. The task dealt with the development of new, innovative car sharing and van sharing concepts. The students were divided into eight teams of six members each. As part of the second phase of the *ProVIL* - process, the phase *Identifying Potentials*, the students have conducted several creative methods to generate a variety of profiles. In *ProVIL*, the methods that the individual teams have to apply in the respective phases are predefined by the project management. Each team executed three methods of creativity. Six of the teams used the *InnoBandit* and are part of the study. In particular, the criteria of *quantity* and *quality* of method results as well as *agility* in the implementation of methods in agile processes are in focus. In order to validate the *InnoBandit* against these criteria, the students filled in a survey before and after the methods of creativity were conducted. In addition, the results of a project milestone were analysed.

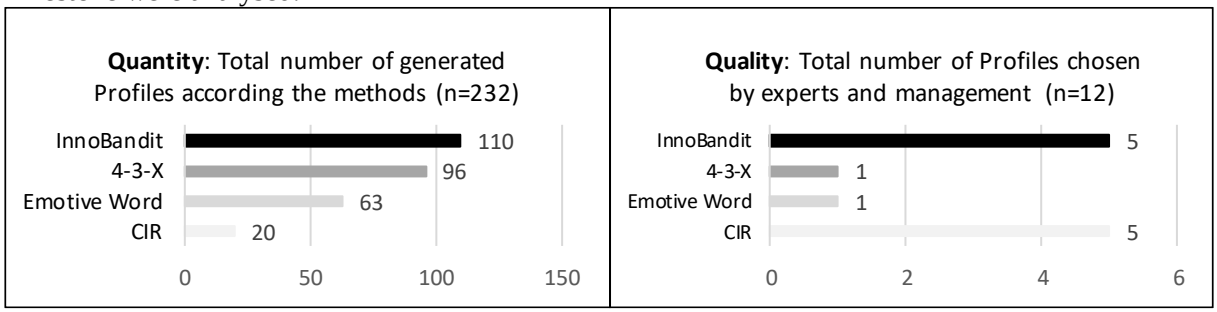

Figure 3. Results from the surveys (left) and from the project milestone (right)

The criterion *quantity* represents the number of generated profiles or ideas. For this purpose, all profiles of the six teams were documented and assigned to the sources *InnoBandit*, *4-3-X method* and *Emotive word method*. In addition, profiles and ideas that were not created during creativity methods were stored in the teams' continuous idea repository (CIR). As can be seen in **Figure 3.** (left), the use of the *InnoBandit* generated the largest proportion of the profiles at 46%. This shows that the *InnoBandit* is superior to other methods in terms of *quantity*. When validating the *quality* of the *InnoBandit*'*s* results, a project milestone was analysed. Experts in the context of development and design methods and the management of the project partner made recommendations to the teams regarding the profiles, which were to be followed up. A positive recommendation is considered the criterion of *quality* in this study. **Figure 3.** (right) clearly shows that the profiles generated during the *InnoBandit* also impressed in terms of *quality*. The 42% share of the total number of recommended profiles suggests that the *InnoBandit* successfully supports the creative process. The third analysed criterion was *agility*, which means that a large number of results (*quantity*) with a high degree of maturity (*quallity*) can be generated in a short period of time. With regard to the criterion *agility*, the average profiles per team were counted and assigned to the particular methods (**Table 1.**, column 2: # generated profiles = total number of generated profiles/number of Groups (=6)). In addition, the average time per implemented method was documented (**Table 1.**, column 3) and the key figure of the generated profiles/hour (**Table 1.**, column 4) was calculated on this

basis. The comparison of the three methods carried out by all teams shows, that the *InnoBandit* can improve the efficiency of the creation of creative results in terms of *agility* (significance level 5%). However, it should be noted, that other methods are also suitable in agile processes (for example 4-3-X) with regard to agility. It could be demonstrated, that all previously defined criteria for agile development processes are successfully fulfilled for the *InnoBandit*.

Table 1. Average profiles/hour using different creativity methods

Creativity method	# generated profiles	Duration Time	Profiles/hour
InnoBandit	18,3	0,75 hours	24,4
4-3-X	12	0,5 hours	24
Emotive Word	5,3	0,75 hours	7,1

In addition to the key figure profiles/hour, preparation time before implementing the method is also an important factor with regard to suitability for agile processes. In the sense of the PGE, a large number of impulse images can be used for development of further product generations. However, an evaluation of the trends is necessary. If social trends change, images have to be exchanged and irrelevant trends have to be forgotten in the sense of intentional forgetting.

6. Findings and Future works

Methods of creativity continue to be an important source of innovative impulses in innovation processes. However, they are often too limited to achieve effective and efficient results. This leads to results that are not based on existing product generations as defined by PGE. In addition, agile processes usually lack the time to iterate the results. For these reasons, a method was presented, which takes into account the current generation of products and possible reference products and promotes impulses for the creative process in a playful way. Studies have shown that especially in processes of ASD the quantity and quality of creative results could be drastically increased with minimal additional effort. Furthermore, the *InnoBandit* is a possibility to deliberately ignore interfering impulse generators in the sense of intentional forgetting in order to concentrate on PGE-relevant impulses. That way, a purposeful alignment of ideation with market demands and thus innovation potential can be established. On the basis of the presented results, further studies can now be carried out in various projects to investigate the transferability of the *InnoBandit* and to continuously optimize the method. In addition, the results presented form the basis for the conception of further agile methods. The procedure for the creation of the *InnoBandit* can also be applied to the development of further methods.

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