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DECONSTRUCTION OF IDEA GENERATION METHODS INTO A FRAMEWORK OF CREATIVITY MECHANISMS

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ABSTRACT

Creative ideas are a central part of solving engineering problems, generating interesting art, as well as developing successful products and innovations. Idea generation methods are a well-researched topic. Specifically, there is significant research that focuses on specific idea generation methods and how they perform. Further, some method classifications have been suggested to help understand the cognitive mechanisms involved in creative ideation as well as the differences between methods. Yet, the discourse is usually on which ideation method outperforms another or how to improve an ideation method rather than the elements, rules, constraints, and activities that comprise ideation methods. In this study 76 well-documented idea generation methods are reviewed and analyzed. We find all analyzed methods consist of 25 mechanisms. The mechanisms are discussed and classified into idea promoting and implementation mechanisms. We suggest that rather than focusing research only on methods, there should be a parallel track of research creating understanding on these mechanisms and their interactions to help increase our understanding of creativity methods, add practitioners understanding on how to get the best advantages out of creativity methods and lastly improve the way practical creativity is approached in education.

Keywords; creativity, idea generation, design methodology, problem solving

1. INTRODUCTION

In order to change the status quo, solve problems, and develop new products, it is essential to generate novel ideas. There are numerous idea generation methods that can help advance the creation of innovative ideas. These methods vary from approximate guidelines and small adjustments in one's behavior to carefully facilitated processes and holistic approaches. In the context of design and engineering activities idea generation usually involves communicating new thoughts and possibilities in a textual, visual, verbal, or tangible form. Generally, idea generation methods work by helping to increase the amount of new ideas, by removing mental blocks that restrain our imagination or widening the scope of search [1]. Designers are also known to tap to existing knowledge and solutions to generate new ideas and possibilities [2] and idea generation methods can also support this process. In the end, the goal of using idea generation methods, is to enhance or facilitate individual or team creativity, in other words help in reaching original and useful ideas those two qualities being the standard definition of creativity [3]. The authors have noticed, when studying, teaching, and using creativity and methods used to enhance creativity, that methods are essentially just compilations of recurring elements, that dictate how the method is carried out and have an effect on our abilities to produce novel ideas in a wide variety.

There is a good amount of research at methodological level focusing on the effectiveness and outcomes of idea generation methods [e.g. 4, 5, 6]. Studies often compare a few methods against each other, which complicates forming a broader understanding and comparing the vast variety of existing idea generation methods. To get past the dilemma of comparing methods against each other, a stream of studies focuses on only certain elements of the methods aiming at finding out if these elements could affect idea generation positively. For example, the effects that empathic priming [7] or use of analogies [8] have on the outcomes of idea generation methods or whether e.g. gallery viewing or rotating ideas sparks more new ideas [9] have been studied.

The previous studies have provided valuable knowledge on idea generation and some of the underlying elements. In this paper we aim at recognizing the multitude of these elements - that we from now on call *mechanisms* - and generating a suggestion for a framework of mechanisms that comprise idea generation methods. Therefore, the main aim of the current study

is to add understanding and theoretical knowledge of idea generation methods by taking a look beyond the methods. This paper contributes to research, teaching as well as to practice First, focusing on mechanisms rather than on mechanisms combinations in the form of different methods, we aim at improving comparability of research on idea generation. Through adding understanding on the entity of mechanisms, practitioners will be, hopefully, able to create novel ways to enhance creativity in idea generation or modify existing methods according to the prevailing needs. This understanding would also benefit engineering and design educators, when new generations of practitioners are taught problem-solving skills. Further, previous research has shown, that understanding the components of idea generation could explain why some idea generation methods prove more effective than others [5]. This paper presents a study, where idea generation methods are searched in literature and their instructions are coded and analyzed to find the comprising mechanisms. The analysis results in a framework of mechanisms that we suggest to be the building blocks of idea generation methods.

2. BACKGROUND

A plethora of idea generation methods can be found in books, websites and to a smaller extent in academic literature. The exact amount of idea generation methods is debatable and also depends on how one defines an idea generation method. Takahashi [10] claims to have identified as many as 300 techniques for solving creative problems, and a variety of books written for practitioners [e.g. 11, 12, 13] present roughly hundred methods for design or problem solving. Some of these methods, however, are designed for phases before or following the idea generation phase. For example, De Bono's [14] PMI (plus, minus, interesting) model is an "attention directing tool" used for making sure all aspects of an issue are considered before making decisions, thus it helps to understand a problem but is not targeted for generating ideas for solving the chosen problem. Further, some methods are structured processes and some are merely tools, pieces of advice or small additions to other methods that can help in triggering ideas [15] or broaden the line of thought. There is a wide range of previous research on idea generation methods, which this study builds on. We will give a short overview of how previous research has shed a light on idea generation methods and mechanisms.

2.1 Idea generation method classifications

Although most studies look into a specific method or a specific mechanism, such as incubation [e.g.16] or modality [e.g. 9], there are also studies that create a more holistic understanding of idea generation methods. The attempt of understanding idea generation methods has been of interest in engineering design and design research, cognitive science, and management science. To form a deeper understanding of the logic of generating ideas, scientists across these fields have classified and made sense of idea generation for example from the perspective of active ingredients [15], through identifying components of idea generation methods for measuring effectiveness of these components [e.g. 5, 6], stages of problem solving process [17], and through the cognitive process of how the problems are solved [e.g. 10].

There are also previous studies on classifying idea generation mechanisms. The closest previous work to the current study is a set of studies, where the aim has been to create a means of measuring the effectiveness of different components in promoting idea generation [5, 6]. Other studies aim to e.g. understand practices of creative professionals [17] or to understand the role creative practice can have in the success of a business. Despite the goals of the studies being elsewhere, they have produced valuable knowledge on idea generation mechanisms. For example, it has been suggested that some idea generation mechanisms are stronger, easier to manipulate, or more complex in terms of interaction than others [6]. In their study Vargas-Hernandez et al. [6] suggest grouping these mechanisms into idea generation principles and components, the principles being higher-level actions such as frame shifting and more fundamental than components such as incubation.

As said, one way in which idea generation methods have been classified is through the thinking process. This is not surprising, as a big part of creativity research focuses on the cognitive side of creativity and most previous studies at least touch upon cognition. One previous way of classifying idea generation methods has been a division into methods of 'free-association', 'forced relationship', 'analytical methods' and 'eclectic methods' [18] and another categorization divides idea generation methods into divergent and convergent techniques, combinations of these two and attitudinal techniques such as 'dramatic' or 'meditative' techniques [10]. Smith [15] suggests that we need to first understand the essential mechanisms of idea generation methods and their connections to cognitive processes to understand how idea generation methods work. In order to result in new ideas a method must trigger our cognition. This is achieved through active ingredients – or mechanisms - that can be for example stimuli or a condition fostering idea generation such as anonymity. According to Smith [15] there are three types of active ingredients in idea generation methods. First ingredients are strategies that are mostly mental active means of generating ideas [15]. Second are strategy-supporting tactics - mostly different kinds of stimuli - and finally enablers that passively support idea generation by fostering conditions beneficial for it [15]. Herring et al. [17] present a categorization and creative model to categorize idea generation tools used by creative professionals. The categorization of methods comprises of three fluid phases of 'research', 'represent', and 'refine' that are all accompanied by inspiration [17].

Idea generation methods have also been classified purely into cognition–based categories. Shah et al. [5] classify methods into logical and intuitive methods, and similar classifications have been done by others as well [e.g. 19]. Intuitive methods are methods that facilitate idea generation by stimulating unconscious thought processes. Logical methods are more systematic ways of solving and understanding the problem in hand. [5] As their aim was to move to a more detailed, componential level than cognition Shah et al. [5] also present a

set of idea generation components that are present in idea generation methods. These components are divided into two categories based on their way of functioning; 'idea generation promoters' e.g. use of analogies and 'tackles' that help overcome a mental block e.g. suspending judgment, which helps to mitigate the effect of too early criticism [5]. In this categorization, e.g. group size or cycle time are ruled out of the categorization as method related operating variables, along with design problem variables, human factors, and environment variables [5]. In this previous classification one idea generation method can contain multiple components or elements of multiple approaches. In this work, we update and build on these past classification schemes, without taking a stand on the fundamentality or importance of individual mechanisms.

2.2 Idea generation methods and mechanisms in literature

Studies, that focus on idea generation methods can be roughly divided into two tracks. In the first track studies compare methods against each other while the other track focuses on adding understanding on what effect a certain idea generation method has on designing as an activity or the outcomes of it (e.g. 4, 20, 21].

However, previous research has not only compared methods and tried to understand the effectiveness of methods, but it has also looked deeper into mechanisms that differentiate methods from another. This kind of research includes for example priming designers with empathic experiences in order to help them empathize with users while generating ideas [7], finding analogies in idea generation with a new design by analogy method [4], the effect of time and incubation to problem solving [16, 22] or the use of design heuristics, cognitive strategies that allow a designer to explore existing possibilities [21, 23]. Often the interest of researchers is how mechanisms such as stimuli, cognitive priming, evaluating ideas or modality affect idea generation [e.g., 20, 24, 25, 9] or what is fixation [26], what causes it and how to mitigate its effects [27, 28].

For example, we know that modality of generating ideas is a mechanism that can have a great effect on the ideas that result from an idea generating session and it has been studied in many ways. For example, variations and modifications of Osborn's [29] Brainstorming have been compared against each other to understand the effect of modality. It has been found out, that written techniques (brainwriting techniques) can overcome many challenges that classical or other verbal versions of Brainstorming have. Written techniques ensure equality of the participants, and push them to participate, eliminate the effect interpersonal dynamics can have on the session, and can produce more and better quality ideas than classical Brainstorming [30]. Also visual techniques have been studied and compared to e.g. written techniques. When comparing Collaborative Sketching (C-Sketch) [e.g. 31] with Method 6-3-5 [32] the sketching method has been found to be more effective when measuring quality, novelty, and variety of designs [31]. While sketching can stimulate creativity in a team [33] and produce more and higher quality ideas that written methods, there are also indications that by combining these two modalities the results would be even better when measuring quantity of ideas [9].

The current study builds on this existing knowledge and work on idea generation methods and mechanisms by systematically decomposing well-documented idea generation methods in order to find out the full set of mechanisms present in current ideation methods. We aim at shifting the focus from studying individual methods and mechanisms through methods to studying mechanisms, as some studies visited in this section have already successfully done. Understanding the mechanisms in their entirety is a step towards this.

3. METHODOLOGY

This study adopts a qualitative approach, where documented idea generation methods' instructions are used as the stand-alone data.

3.1 Data gathering

The data used in this study was gathered by reviewing previous research, books, and Internet sources on idea generation methods and creativity improvement guides. The search was not limited only to scientific sources, as idea generation methods are practical tools and there is an abundance of methods presented by and for design practitioners online and in various design books. First idea generation methods were searched, followed by collecting the instructions for each method. The instructions were concerned as data that has been produced for practical purposes [34] of idea generation and the analysis. Some of the used instructions were *primary documents,* i.e. the original descriptions of a method, while some of the method instructions we used were *secondary documents*, meaning that the method was described by someone else than the originator. We do not see this as a limitation, as this is in the nature of practitioner-oriented idea generation methods. However, the original descriptions and instructions of methods was used when possible. For some methods multiple documented instructions were consulted to create a better understanding of the procedure. The concept of inductive thematic saturation was applied in this study, i.e. new data was gathered until no new idea generation mechanisms were found in the method instructions as new methods were found (see Figure 1).

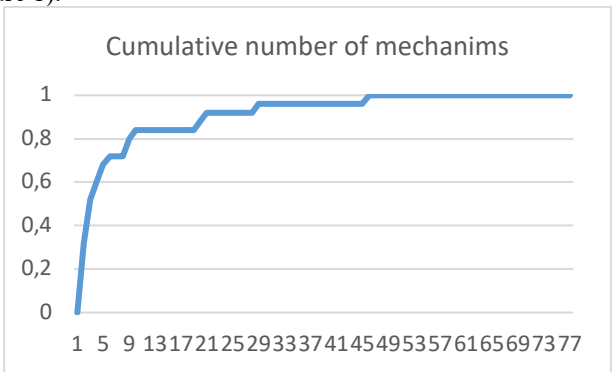

FIGURE 1: CUMULATING NUMBER OF MECHANISMS FOUND

The analyzed method instructions included different level idea generation methods. At one extreme were processes that take the participant(s) from problem formation to choosing the idea or ideas to be further developed whereas at the other extreme were methods that are instructed to be implemented in other methods or used alone in order to spark ideas. Despite this difference in the level of intensity all of the methods included in the analysis had the same aim – to help people generate ideas. Despite the differences in the level of comprehensiveness all methods were analyzed in the same manner, focusing on the instructions and descriptions of the methods. In our definition of what constitutes as a method in this study we therefore follow Smith [15] (p.109) when he writes, "A technique is a prescription. They range from highly structured procedures to informal pieces of advice."

3.2 Inclusion and exclusion criteria

The collected data included in the end 114 methods and their instructions. This study focused only on methods that were created for idea generation phase of a design process. There are plenty of methods that are created for previous or following phases of a design process. These are useful for helping in understanding the problem at hand, selecting ideas or in taking the ideas further, and developing them into feasible concepts. However, those methods are outside the scope of this study. Therefore, some of the collected methods were ruled out from the analysis. For example, Factorization that was suggested as a systematic problem solving method by Pahl & Beitz [19] was left out, as it is a method for defining and breaking down the problem before idea generation rather that a method for generating solution alternatives. Idea generation methods that were not actionable i.e. had no clear instructions were ruled out as well. For example, Prototyping [17] is certainly useful in idea generation, but this method had no clear instructions, thus it was ruled outside the scope of this study as a non-actionable method. If a method's only instruction was a suggestion such as to let one's mind wonder or to think laterally and understand the big picture, they were also ruled out of the analysis as non-actionable. Even if the method's essence might have sounded vague or general (e.g. to take a break from idea generation), it was included in the analysis if there was an actionable instruction for how to put it into action.

After checking each method against the inclusion criteria **76** idea generation methods were included in the final analysis (See Appendix A for a list). Some of these 76 methods were modifications of other methods, but the modification was included in the analysis if its instructions were different from the previous method. In cases where the execution of a session would be identical to other modifications of the same technique, only one method was chosen for analysis. Methods that were identified as the same method under different names were treated as one in the analysis. For example, SCAMPER [35] and its extension SCAMMPERR [36] were taken into account only once under the name of SCAMPER as the extension is only adding two stimulating action verbs and not changing the execution of the method.

3.3 Data coding and analysis

The final set of method instructions was divided into steps method by method. The coding consisted of searching these steps for descriptions of how to put the method in use and highlighting each independent segment. These segments were then coded into categories based on the described mechanism (Table 1). The coding categories of mechanisms were developed iteratively during the data gathering and analysis.

	Segmented method instruction	**Coded mechanisms**
Forward steps Described by Pahl & Beitz [19]	"Starting **from a first solution attempt**, one **follows as many paths as possible to produce further solutions**. This method is also called the **method of divergent thought**. It is not necessarily systematic, but frequently starts with an unsystematic **divergence of ideas**. The method is illustrated in Figure 2.21 for the development of a shaft–hub connection (coder's note; **drawings** and **writing** describing solution possibilities). The arrows indicate the direction of the thinking process. Such **a thinking process** can be improved by **using classifying criteria** (coder's note; a figure including **stimulation** words) to support the **systematic variation of the characteristics** (coder's note; an example figure). Where variation is done without conscious thought, even with well-structured representations, the identified characteristics are not used to their full potential."	Open-ended duration, Aiming at high amount of ideas, Modality: drawings, Modality; written Modality: thought process, Classification of ideas, Stimulation, Combination & modifications,
Design Heuristics [46]	We developed a set of Design Heuristics that are intended to facilitate idea generation. Instead of aiming to generate a single solution, the **goal is to promote the generation of multiple, diverse ideas** through **repeated application of different Design Heuristics**. For the current study, each heuristic is presented in the **form of a card,** which includes a title, a descriptive action prompt, an abstract image, and **two product examples.** On the front of the card, the **action prompt** provides specific instructions on **how to modify an existing idea, or gives features to build a new idea**. The **abstract image is intended to supplement the action prompt** by representing it visually. On the back of the card, the **first product example comes from a variety of consumer products,** while the **second one offers an example from a consistent object** (seat or chair). This is to show that the heuristics apply to a wide range of products and that every heuristic can be applied to the same product category. // Students were asked to **draw their concepts** on separate papers.	Team/ Individual; Open-ended duration (detailed elsewhere in the source) Aiming at high amount of ideas, Special tool (cards) Stimulation Combination & Modifications, Modality: Visual

TABLE 1: EXAMPLE OF SEGMENTING AND CODING MECHANISMS FROM A METHOD INSTRUCTION. THE FOUND MECHANISMS ARE BOLDED IN THE EXAMPLE.

The categories rose both from literature and the data. The analysis started with literature-based categories. For example, the first phases of coding included a category of a "specific problem", which illustrated the starting point of the session and whether the problem was explicated as it appeared in some of the method descriptions. It was later removed as the authors came to a conclusion that having a specific problem to ideate around is an implicit assumption in all situations where idea generation methods are used. Some categories were also merged. In the first phase of coding there were separate categories for inspiration and priming. Later these two and all other stimuli were categorized in one category of stimulation, as both using inspirational material [37] and priming essentially are about presenting cognitive stimulus to activate and affect one's thinking [38]. Finally, a clear definition was created for each category, and the definitions were used in coding all the methods.

In the end we identified 25 final mechanisms that we used as the final coding categories (Tables 2 and 3). Based on thematic similarity the coding categories were divided into two top level types, implementation and idea promoting mechanisms, and further six sub-types. This division will be further discussed in Section 4.

Implementation mechanisms	
Mechanism	**Definition of the mechanism**
Team	Methods that can be used or are designed to be used in a team. Even if the method is for team use it might contain phases where participants work individually. These kinds of methods were tagged only as team methods, as they are unfunctional without the team element.
Individual	Methods that can be used or are designed to be used individually. If a method can be applied both for a team or an individual it contains both mechanisms.
Given duration	Duration for using the method is given.
Decide duration	Duration for using the method is up to the users to decide.
Open-ended duration	Duration for using the method is open, the session ends when no new ideas emerge or the instructions have no mention of duration.
Written modality	Ideas are written down as they emerge. For example, an advice to "make a list" would be an example of written modality.
Verbal modality	The ideas are expressed in a spoken, verbal form. If ideas are first only spoken out loud and then collated into a list in the end of the session as a way of collecting them for further use, the only acknowledged mode is verbal.
Physical modality	Ideas are generated and expressed by acting physically.
Visual modality	Ideas are expressed as sketches and drawings. Mock-ups or low fidelity prototypes also count as visualizations of ideas.
Thought modality	Idea generation is done as a chain of thought.
Facilitation	A facilitator leads an idea generation session. The facilitator might just keep track of the activities or lead the session without taking part in generating ideas.
Special tool use	Using a tool such as a ready-made form, matrix, game or software as a part of the idea generation session. Tools such as sticky-notes or paper were not coded as special tools.

TABLE 2: DESCRIPTIONS OF IDENTIFIED IMPLEMENTATION MECHANISM CATEGORIES

Idea promoting mechanisms	
Mechanism	**Definition of the mechanism**
Analogies	Utilizing analogies in idea generation session. Participant(s) are guided to draw analogies from one domain to another. The sources of analogies can include e.g. other industries, nature or products. Analogous designs share at least one function or behavior [e.g. 39].
Association	Using associations, i.e. generating ideas with the help of associations from e.g. words, previous ideas, pictures, situations or nature.
Building on others	Participants are encouraged to build on others' ideas while the ideas are created or stated. Also rotating ideas or thoughts to other participants and building on those ideas.
Incubation	Incubation period or phase as a part of the method. It is a period of time when problem is set aside before going back to solving it [e.g. 16].
Stimulation	Using stimuli to prompt ideas. For example, using stimulating pictures, questions or words or adapting a role to tease out ideas. Method might include collecting and using inspirational material or influencing the subconscious either by exposing the participant(s) to pictures, sounds, words or other ways to influence idea generation and activate thinking to help in accessing already existing knowledge.
Aiming at a high amount of ideas	An emphasis on quantity, and an aim to create a mass of ideas as opposed to creating only few ideas. This is often implicit in method instructions, or this might be the result of repetition of certain steps as e.g. in Method 6-3-5.
Classification	A phase in an idea generation method where ideas are classified or grouped as a part of using the method.
Combination & Modifications	Combining, synthesizing or modifying ideas as a part of the idea generation session in order to create new ideas and meanings. Modified ideas can be either ideas created during the session or existing products, things, ideas or meanings.
Evaluation	A phase in an idea generation method where ideas are evaluates as a part of using the method.
Framing	Framing here includes rephrasing or re-framing the problem. Cutting the problem into smaller entities or maybe reversing it. Sometimes there is a focus on setting the problem into a context or defining the problem before starting to generate ideas to solve it. This is done in order to eliminate constraints and widen or limit the scope of search.
Iterations	Iterative process in idea generation methods, where ideas are generated cyclically.

Selection	A phase in an idea generation method where one or more ideas are selected for some further use, to be e.g. generated further, built upon, to be presented or to be shared.
Suspend judgment	Suspending premature judgment and evaluation of ideas during idea generation in order to produce a variety of ideas. Sometimes method instructions do not specifically state to suspend judgment, but to be open to e.g. "crazy ideas" or "all ideas".

TABLE 3: DESCRIPTIONS OF IDENTIFIED IDEA PROMOTING MECHANISM CATEGORIES

According to the instruction segmentation, each method was coded either belonging (1) or not belonging (0) to the developed coding categories. This decision was made by judging whether the mechanisms the categories represented were found in the segmented method instruction or not (Table 1).
If the segment included examples of or references to e.g. drawings it was assumed that the participants were being advised to draw even if drawings were not explicitly mentioned. Some instructions included also scales from one to five describing whether the method was useful for an individual or a team. In a case of the participants not being mentioned in the instructions this kind of indicators were taken into account as a part of the coding. Otherwise only mechanisms mentioned explicitly in the segments were coded into the relevant categories. The categories are not mutually exclusive. A method could for example be both team and individual method or utilize both stimulation and analogies.

3.4 Inter-rater reliability analysis

To ensure the reliability of the primary coders coding decisions, a second coder coded 15 % of the data. The second coder worked independently starting from a randomly selected set of method instructions. The segmented steps and mechanisms found by the initial coder were not available for the second coder but he searched for those himself. The second coder then proceeded to decompose the methods into categories. The initial Cohen's Kappa for the all the categories together was 0.82, ranging from 0.42 to 1. However, in seven categories the coders disagreed in multiple cases and the initial Cohen's Kappa in those categories varied from 0.42 to 0.62. These categories were re-coded with an improved coding instruction. After re-coding Cohen's Kappa for the all the categories together was 0.93, ranging from 0.74 to 1. Cohen's Kappa over 0.7 is regarded sufficient [40]. Once this Cohen's Kappa was achieved a single coder continued to code the rest of the data.

4. RESULTS

This chapter discusses the results of analyzing the instructions of 76 idea generation methods. The results are divided into two sections based on the idea generation mechanism types identified as a part of the analysis. We found there are two types of mechanisms (Tables 2 and 3): implementation mechanisms and idea promoting mechanisms. Implementation mechanisms define the practicalities of an idea generation session; therefore, they could be seen as the functional characteristics of the methods. They concern for example how long an idea generation session takes, who takes part in it and how the ideas are expressed. They are not idea triggers as such but more technical level details of utilizing a method. Idea promoting mechanisms advance the generation of ideas by triggering cognition through either the sources or process of generating ideas. These two types of mechanisms could be further divided into subtypes based on their characteristics. The methods analyzed as a part of this study consisted of three to thirteen mechanisms with an average of 6,8 mechanisms per method.

4.1 Implementation mechanisms

The implementation mechanisms we found could be divided into four sub-types. These include mechanisms defining participants, modality, duration, and use of supporting tools. We will describe the categories belonging to the sub-types as well as their occurrence in the analyzed 76 method instructions.

Participants

The method instructions included instructions to either use the method individually or with a team. Majority of the methods, 53 % (40), were reported as team only methods while 20% (15) were meant for only individual use. Fifteen of the methods (20%) could be used by either a team or an individual and 8% (6) of the method instructions had no indication whether it was for team or individual use. Altogether 72% (55) of the methods were team methods and 39% (30) were individual methods.

Modality

The modality categories described the mode in which the ideas were expressed during idea generation. Most methods utilized writing at least in some phase, with 63% (48) being written methods. Out of all the methods 36% (27) were verbal, 20% (15) were indicated as thought processes, 16% (12) utilized drawings, and only 4% (3) had physical modality. Most methods, 59% (45) utilized only one modality while 37% (28) of the methods utilized or could be done in two or more different modes. The modalities occurring together were usually written and verbal modality (25%, 19 methods) possibly accompanied with other modalities as well. Out of all analyzed methods 30% (23) were written only, 12% (9) were thought only, 7% (5) were verbal only, 7% (5) were visual only, and 4% (3) were physical only in regards of modality. The instructions of four methods (5%) did not specify or indicate the modality.

Duration

We found three types of duration in the instructions; open-ended, given or cases where the duration is to be decided by the participant(s). Most of the method instructions 79% (60) did not specify the time to be used in a creative session but instead the duration was open. These sessions could be run as long as ideas emerge, or when the participant(s) feel like ending the session. In 18% (14) of the methods participant(s) were instructed to decide on the duration of the session and in 11% (8) methods the timeframe for the session or some parts of it was given in the instructions (e.g. Method 6-3-5). In 4% (3) of the methods duration was both open and for the participant(s) to decide and

in 5% (4) there was a given duration and/or the participants could decide. The latter was usually due to different phases of the session having different instructions regarding time.

Supporting tools

Some of the coded segments described using tools to support ideas generation. We identified two supporting mechanisms; having a facilitator and using a special tool. Facilitation was required, suggested or otherwise indicated to be used in 30% (23) of the methods. This could be either a participant in the session or a person whose only task was to facilitate the idea generation session. A special tool was used by 16% (12) of the analyzed methods. The tools varied from databases and ready-made templates to online platforms or programs.

To summarize, most common separately manifested implementation mechanisms were open-ended duration (79%), team as idea generator (72%), written modality (63%) individual as the actor (39%), and facilitation. The rarest implementation mechanism was by far physical modality with only 4% of the methods taking advantage of that. Given duration (11%), duration to be decided (18%), and visualizations as modality (16%) were also relatively rare mechanisms, with a big difference to the most common implementation mechanisms that were also duration and modality related. One of the five rare implementation mechanisms that stood out was special tool use, with only 16% of the methods utilizing special tools. The tools varied from databases and ready-made templates to online platforms or programs.

4.2 Idea promoting mechanisms

The idea promoting mechanisms we found were divided into two sub-types. They are idea source- and process-related mechanisms. We will describe the categories belonging to the sub-types as well as their occurrence in the analyzed methods.

Idea sources

This sub-type includes five identified mechanisms; association, analogies, building on others, incubation, and stimulation. These mechanisms work as cognitive triggers to help producing new ideas. The use of different kinds of stimuli to trigger creative thinking and promote idea generation turned out to be very common, as 55% (42) of all 76 methods had elements of e.g. going through inspirational material, using stimulating words or roles or priming the participants minds. In 29% (22) of the methods participants were guided to build on others ideas as a way of generating new solutions. Using analogies was advised in 18% (14) of the methods, and making associations was utilized in 12% (9) of the methods. Incubation was utilized in 5% (4) of the method instructions.

Process

A group of process defining mechanisms was also identified in the idea promoting mechanisms. These mechanisms seem to help idea generation through adding such phases to the process that force or facilitate producing new ideas. The following mechanisms were identified; aiming at a high amount of ideas, combining and modifying, suspending judgement, classification, evaluation, iterations, framing, and selection. Taking advantage of combining and modifying existing products and concepts or ideas generated in the session was present in 38% (29) of the methods. An equal amount of methods, 22% (17) included a phase of framing the given problem and advising towards suspending from judgement during idea generation. Aiming at high amount of ideas was described in 21% (16) instructions, phases of evaluating as well as iterating were nearly as common, being present in 17% (13) and 18% (14) of the analyzed instructions. Classifying or selecting ideas as a part of the session was rather rare in the methods, with classifying showing up in 11% (8) and selecting in 9% (7) of the analyzed methods.

It can be seen, that the majority of the identified idea promoting mechanisms manifested in the methods quite evenly, while few mechanisms stood out as more common or rarer than others. However, three mechanisms stood out as the most common and four as less used idea promoting mechanisms. The most common idea promoting mechanisms were using stimuli (55%), combination and modifications (38%), and building on others ideas (29%). The most seldom occurring idea promoting mechanisms were selection (9%), classification (11%), incubation (5%), and association (12%).

5. DISCUSSION

In the presented study 76 idea generation methods were collected and analyzed from the perspective of the method comprising elements we call mechanisms. This section discusses the findings, based on which we suggest a framework for of idea generation mechanisms, and their relevance.

The results suggest that idea generation methods consist of two types of mechanisms. These mechanisms either dictate the implementation of the method, how an idea generation session should be set up, or act as promoters for idea generation by bringing process- or cognition-related elements to an idea generation session. Most studies on idea generation methods focus on understanding the effectiveness of certain method or the effect of a certain mechanism. The main contribution of this study is an updated understanding of the entity of idea generation mechanisms. We also present suggestive findings of their frequency in methods. These mechanisms constitute the backbone of all idea generation methods (Figure 2).

It should be noticed, that as a part of this study no attempts of forming a hierarchy of these identified mechanisms were made. This is something that could be pursued, and a difference of the level or how fundamental each mechanism is can be noticed in the results, and is in line with the work of Vargas-Hernandez et al. [6]. Some of the discovered mechanisms are cognitive while some are practical– however, this is how method instructions where these mechanisms were drawn from are. The current study does not address this difference. Thus, the aim, potential use, and value of the framework is in making an attempt of providing a holistic view of the multitude of mechanisms that are at play when applying the mechanisms in practice.

We also found, that as idea generation methods seem to consist of mechanisms that occur often in seemingly very different methods, it was not possible to group the analyzed methods themselves into categories defined by these mechanisms (a cluster analysis was attempted, but the results showed no clear

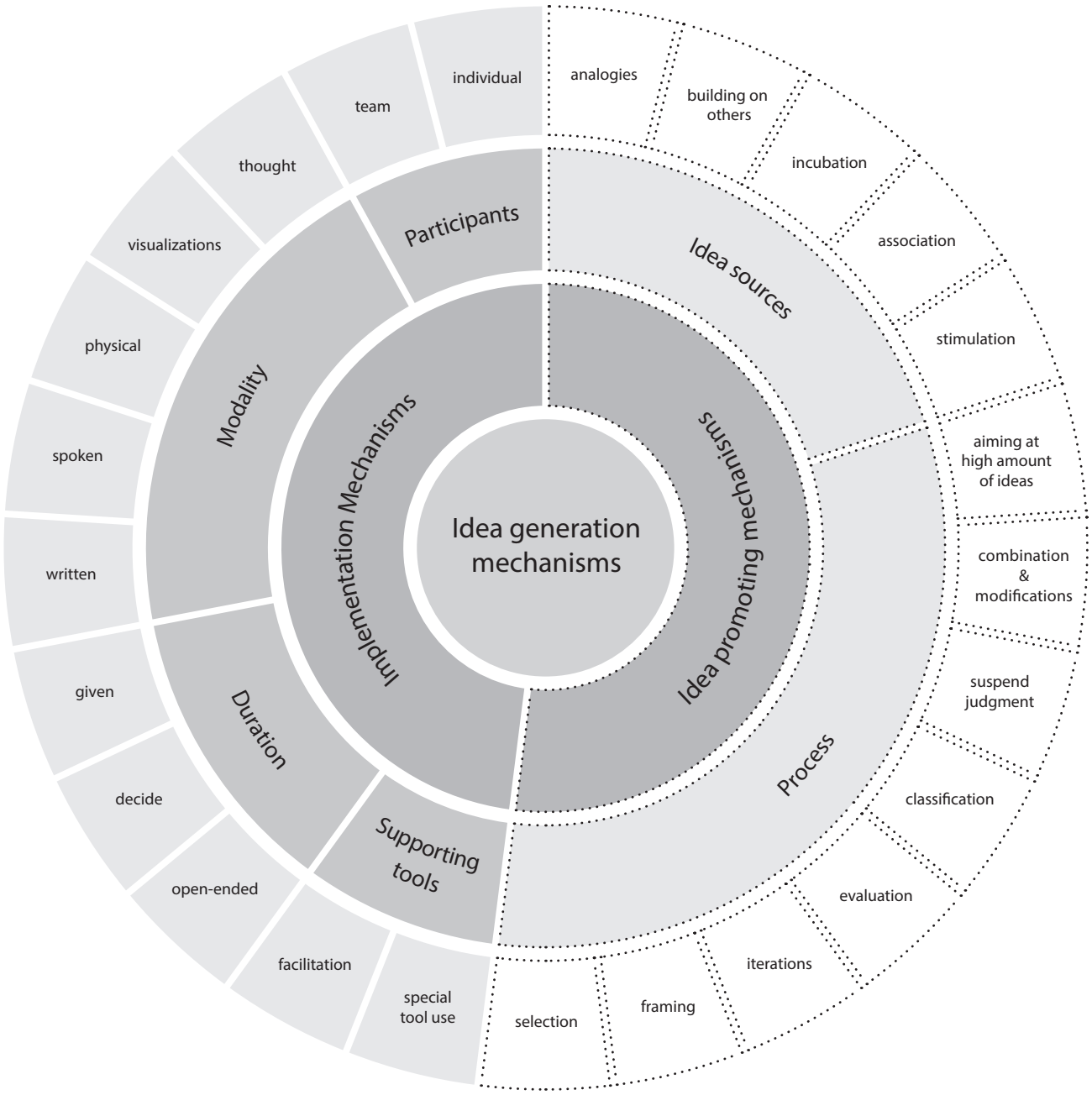

FIGURE 2: THE SUGGESTED FRAMEWORK OF CREATIVITY MECHANISMS IN IDEA GENERATION METHODS

method types, groups, or patterns.) For example, when comparing e.g. Bodystorming [41] and Mind-mapping [42] against one another, they appear at first hand quite different. One immerses participants physically into the situation or problem at hand and stimulates thinking through action while the other stimulates thinking through systematically solving a problem branch by branch in writing. The instructions differ in implementation mechanisms (modality, duration, and participants) but they share an important idea promoting mechanism – stimulation. This similarity can be seen when decomposing the methods into mechanisms. If we were to reduce the implementation mechanisms the two methods appear alike. Therefore, we suggest that research on idea generation should look beyond methods, as but the entity is more complex. Studying methods instead of mechanisms the results we gain are not as comparable if when focusing on mechanisms. Effectively, comparing a method to another is actually comparing a specific group of mechanisms and their interactions. While that is also a valuable goal, a more basic understanding of the mechanisms alone and their simpler interactions should be gained first.

As said, the identified mechanisms differ from each other and they affect idea generation on various levels. Therefore, we

suggest, that comparing studies should be planned in a way that the comparisons are relevant. Comparing mechanisms across the two identified types or sometimes even subtypes of mechanisms is not necessarily something that should be pursued. However, comparisons between mechanisms that can be used as alternatives to each other can produce interesting knowledge on these mechanisms [43, 44]. This has also been the case is previous studies, where e.g. modality has been studied [9, 33]. For example, as sketching has proven to be more efficient than writing only [31]. Method 6-3-5 has also evolved into using visual techniques, instead of only writing down ideas. There are multiple possibilities for testing different mechanisms in action, for example, what is the effect if you add classification to SCAMPER or change the modality of e.g. Rolestorming [45] into visual.

There were some mechanisms that were found in only a few method instructions and some that dominated the methods. For example, incubation appeared only in four methods, which was a surprising discovery, as incubation is a well-researched mechanism that has a positive effect on idea generation by widening the search for solution to new areas [16, 22]. When a problem is re-approached after an incubation period the search is extended [16]. Understanding the benefits, incubation seems to be an under-exploited mechanism in the existing idea generation methods based on the results of the current study. Also classifying or selecting ideas during the idea generation session were little used. They are also mechanisms whose effects on idea generation have not been widely studied. However, both have been shown to have a positive effect on idea novelty [43]. One dominating mechanism was written modality with 63% when comparing to visual modality (12%) as of the methods exploit writing. This is in conflict with what we know of the benefits of visual [33] or combined visual and written modality [9]. Using open-ended duration, that dominated the methods (79%), is backed up by previous findings that show how longer periods of time used for idea generation positively affect the diversity of the solutions created [22]. The value of recognizing dominating or underused mechanisms is in the possibilities of adapting methods, mixing mechanisms or even creating whole new methods that answer the needs of each situation. The reason some well researched mechanisms, or mechanisms recognized as dominant in creativity and learning, were not more recurring in the data could be, that in reality these useful ways of advancing creativity are not present in the method instructions. Instead they might be mechanisms that practitioners intuitively gravitate towards without being instructed to do so.

Modifying methods based on mechanism knowledge and current need could create better starting point than possibly choosing a method or even modifying it based on intuition, which is what often happens in practice. Thus, one of the applications of the results presented here, is to use the framework as a tool to become aware of ones' choices and possibilities, so that idea generation can be varied to reach a larger variety of ideas if one wishes to do so. Recognizing the mechanisms in methods helps in modifying the methods but also in searching for different methods to be taught to future designers or to be used in a project by practitioners. Design students are usually taught and professionals know a suite of creativity methods. By becoming aware of the mechanisms that make each method we can make more conscious choices and selecting methods that consist of different mechanisms. This could help students in understanding the vast variety of idea generation methods and their relevance for creativity. We see, that making conscious choices to widen the variety of creativity promoting mechanisms can also help practitioners striving to create innovative ideas. A recent study showed, that cognitive support – Design Heuristics in this case - could help in pushing past the exhaustion point of creativity and generating additional, even more novel ideas [23]. We suggest that the framework resulting from our results could be used as tool for finding actionable supporting mechanisms to try in similar situations.

We identify also some limitations in the current study. First, the documented method instructions used as data are only one interpretation or description of each method. The results might be slightly different if synthesizing multiple instructions into one for the analysis. However, in some cases this was done, as described in Section 3. What might also bias the results regarding the occurrence of the mechanisms is that all instructions do not specify e.g. modality, if there are iterations or if the method should be used by individuals or team. In those cases, these mechanisms were not coded which might cause a bias. Therefore, the results regarding the frequency of mechanisms cannot be generalized.

There are also idea generation methods that could not be included in this study because no instructions were available. Many methods are used in practice as modifications of methods and there are multiple variations of Brainstorming for example. These variations were not searched for or taken into account. However, as the aim of this study was in identifying mechanisms rather than in identifying methods this should not affect the results.

6. CONCLUSIONS

A framework of 25 creative mechanisms with a division to idea promoting and implementation mechanisms was generated. These groups can be further divided into sub-types. The division generated as a part of this study consists of two sub-types for idea promoting mechanisms: idea sources and process related mechanisms. Idea sources include mechanisms that are actively used to prompt ideas. These mechanisms are analogies, association, building on others, incubation, and stimulation. Process mechanisms are related to how the idea generation process is carried through and the concrete steps of action. The sub-group consists of the following mechanisms: aiming at high amount of ideas, classification, combination & modifications, evaluation, iterations, framing, selection, and suspending judgment. The implementation mechanisms are divided into four sub-types that are duration, modality, participants and supporting tools.

When moving to a more detailed level, more mechanisms could be formed. For example, stimulation as a mechanism can be further divided into different forms of stimulation according

to what kind of stimuli is used or how the stimulus is used. Likewise, visual modality could be further divided into different ways of visualizing, for example building prototypes to think by doing and sketching. We also considered a possibility to combine some of the identified mechanisms, as there is some overlap between them. For example, we acknowledge that using analogies and association are closely related actions. However, in this framework they are kept apart, as they were separately mentioned in the data and they have different definitions.

We suggest approaching idea generation mechanisms as building blocks or a "cook book" that allows trial, play, and being creativity about the creativity methods. Looking at idea generation mechanisms as almost interchangeable blocks opens up a nearly endless possibility for generating new methods or modifying idea generation methods by switching or adding mechanisms into existing methods.

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APPENDIX A

The 76 methods included in the analysis, named as they appear in their instructions

1. Brainstorming
2. Reverse Brainstorming
3. Starbursting
4. The Charette Procedure
5. Crawford slip writing method
6. Round-robin brainstorming
7. Rolestorming
8. Role-play
9. Electronic Brainstorming
10. Brainwriting
11. 6-3-5
12. Pool method
13. Idea card (pin card) method
14. Post-Up
15. Constrained brainwriting
16. Electronic Brainwriting
17. The spreadsheet technique
18. Interactive brainwriting
19. Brainwriting game
20. Metaphorical thinking
21. Reversal
22. SCAMPER
23. Attribute listing
24. Morphological analysis
25. Matrix analysis
26. Six thinking hats
27. Po (Provocation)
28. Talking pictures
29. The list of 100
30. Listing
31. Heuristic ideation technique (HIT)
32. Design Heuristics
33. TRIZ
34. C-Sketch
35. Concept generating matrix

36. Ideation session
37. SDI
38. Laddering
39. Synectics
40. Delphi Method
41. SIT
42. Concrete stimuli
43. Forced analogy
44. Gallery
45. Passive searching
46. Storyboarding
47. Braindrawing
48. Brain sketching
49. Nominal Group Technique
50. Bodystorming
51. Assumption Busting
52. Brainmapping
53. Challenge
54. Essence
55. Forced Conflict
56. How-How Diagram
57. How to
58. The Kipling method
59. Lotus Blossom
60. Chunking
61. Mind-mapping
62. PSI
63. Random Words
64. Remembrance
65. Rubber-ducking
66. Take a break
67. Pause
68. Greetings cards
69. Unfolding
70. Value Engineering
71. Wishing
72. Concept metaphors and analogies
73. Ideation game
74. Word tree design by analogy
75. Forward steps
76. Backward steps