TOWARDS A TAXONOMY OF IDEA GENERATION TECHNIQUES

Kai WANG

Kean University, College of Business and Public Management, Union, New Jersey, USA
e-mail: kaiwan@kean.edu

Abstract: Business organizations often need to manage creative work. An important way of promoting creative work is to use idea generation techniques (IGTs). Numerous IGTs have been developed, and choosing from such a big pool of candidates can be demanding, which is further complicated by the elusiveness of the mechanisms of these IGTs. This study aims at developing a taxonomy for IGTs based on their underlying mechanisms of supporting ideation. First, the current literature for the classification of IGTs is reviewed. Then some related creativity theories are consulted and a new classification system is proposed based on these theories and previous studies. Eighty seven IGTs are classified according to the system. The implications for research and practice are discussed.

Keywords: innovation, creativity theories, creativity techniques, idea generation, classification.

JEL: O31, O32, M10, M19.

1 Introduction

New and useful ideas have been a major driving force for business organizations. Relatedly, creativity has been intensively studied for decades in multiple disciplines, such as psychology, business management, and information systems (IS) (reviewed in Hennessey and Amabile, 2010; Anderson, Potocnik, and Zhou, 2014; and Mueller and Ulrich, 2013, respectively). Many creativity and problem solving techniques have been developed (Siau, 1996; Smith, 1998).

Creativity is not just about idea generation; it can also involve problem construction and idea evaluation. However, idea generation is often an integral part of creative work. An idea generation technique (IGT) can be defined as "a plausibly effective prescription expressing more than common knowledge" to improve idea generation (Smith, 1998). For example, Smith (1998) identified 172 techniques for idea generation. Higgins (2005) collected 101 techniques for creative problem solving, of which 70 are for generating alternatives, such as brainstorming, brainwriting (i.e., silently sharing written ideas in a structured group format), and picture stimulation.

As a result, people have many choices when trying to use IGTs to obtain novel outcomes. However, there is a lack of research aiming at *systematically* classifying these various techniques. As an example, Higgins (2005) put 70 IGTs into only two groups: individual and group techniques. Even though Knoll and Horton (2011), as well as Nagasundaram and Bostrom (1994), described features or characteristics of different creativity techniques, such as cognitive and social structures of techniques and information technology tools, they did not provide a systematic classification scheme that facilitates the matching between techniques and situations. Consequently, despite of the large amount of accumulated knowledge on creativity and problem solving, in practice, the choice of IGTs is typically in an ad hoc manner.

In order to categorize various IGTs, analyzing their mechanisms through the lens of creativity theories is useful. The theories on creativity and the analysis of the mechanisms behind IGT can potentially inform each other and lead to more insights for both theories and practice.

In this article, the literature related to the categorization of IGTs is briefly reviewed. The methods used in this article are explained. Then, a taxonomy, its rationale, and a table of classified IGTs are presented. The suggested use of this taxonomy and its implications for future research are discussed. Note that this article only deals with the techniques for idea generation. Those techniques focused on other stages in creative work, such as problem definition and idea evaluation, are excluded.

2 Method

First, a literature review on the classification of IGTs was conducted. To identify related academic articles, two research databases were used: SCOPUS and Web of Science.

Table 1. IGT Classification in the Literature (*Source:* Author' own research)

Type	Content
Classification of IGTs	Group vs. individual (Higgins, 2005; Van Gundy, 1988)
	Internal connections vs. external connections, i.e., connections involving elements of the problem vs. connections involving outside factors (MacCrimmon and Wagner, 1994; Smith, 1998)
	Analytical (or linear or logical) vs. intuitive (Couger, Higgins, and McIntyre, 1993; Garfield, et al., 2001; Michalko, 2006; Shah, Kulkarni, and Vargas-Hernandez, 2000)
	Free association Forced relationship Analytical Eclectic approaches (these four categories were formulated by Fulmer, 1974) Nominal group process (added by Summers and White, 1976)
	Brainstorming Checklists Different perspectives Structuring Expert knowledge Random input (Grube and Schmid, 2008)
	Identifying/mapping attributes Making possibilities Changing and shifting perspective Making association and analogical thinking Probing emotion and subconscious TRIZ (Lau et al., 2009)
	Paradigm preserving Paradigm stretching Paradigm breaking (McFadzean, 1998)
	Jumping Pumping Dumping (Knoll and Horton, 2011)
Criteria for Classifying IGT	Cognitive structures, such as stimuli availability and stimuli relatedness; Social structures, such as interacting or noninteracting Procedural structures, such as simultaneous or turn taking (Nagasundaran and Bostrom, 1994)
	Let it happen vs. make it happen; Assimilation vs. accommodation, i.e., change in the problem or its representation vs. the creator's change, such as changing perspectives (Runco, 1999)
	Verbal vs. silent Forced relationship vs. free association Related vs. unrelated stimuli Nominal vs. interactive (for group techniques) Problem scope (broad, medium, narrow) Training importance (low, medium, high) Implementation difficulty (low, medium, high) (Van Gundy, 1988)

The keywords used include creativity techniques, idea generation techniques, and ideation techniques. The articles were screened based on whether they mention any classification of techniques. After this initial search, the author used forward and backward citations to find additional relevant articles. Three well-cited books on creativity techniques (Higgins, 2005; Michalko, 2006; Van Gundy, 1988) were used to identify additional classification schemes. In addition, a Google search using the same keywords was conducted to identify websites that provide classification of IGTs.

Although there are some categorizations of IGT in the literature, a common problem is the lack of connections to creativity theories. The practice of creativity techniques is rarely informed by the recent progress in creativity theories. The lack of systematic classification of IGTs can be partially attributed to this disconnect.

This article aims at developing a theory-based taxonomy of IGTs. Therefore, theories related to idea generation are reviewed. Two types of theories are particularly relevant to creativity techniques: motivational and cognitive theories of creativity (Wang and Nickerson, 2017). Some theories were selected from these types because they had important implications on classifying IGTs.

On the basis of the review of these theories, some criteria for classification were identified and a taxonomy was proposed accordingly. Many IGT types from the previous literature (summarized in Table 1) are used as subcategories in the taxonomy when appropriate. Afterwards, the aforementioned books on creativity techniques (Higgins, 2005; Michalko, 2006; Van Gundy, 1988) were used to identify 87 IGTs. These 87 IGTs were categorized based on the new taxonomy.

It needs to be noted that some IGTs have multiple mechanisms. Consequently, there might be more than one way to classify a specific technique. In those cases, the author tried to use the most dominant mechanism in each IGT to classify. For example, if a technique encourages both implicit associative processing and rule-based explicit processing, the dominant processing mode was identified and used to classify the technique.

3 Background

There are a few studies categorizing IGTs into groups or containing criteria for grouping IGTs. Such studies are summarized in Table 1. The first eight rows are about the actual grouping of IGT, whereas the last three rows are about the criteria for classifying IGTs. Dividing IGTs into individual techniques and group techniques is an obvious option (Higgins, 2005; Van Gundy, 1998). Some researchers pointed out that IGTs can support creative work by facilitating either connections among problem elements or connections to external factors (MacCrimmon and Wagner, 1994; Smith, 1998).

Creative thoughts often result from some stimuli, which can be either related or unrelated to the problem (Runco, 1999). Another distinction among IGT is the one between linear and intuitive tech-niques. It is based on whether the technique depends explicitly on intuition and subconsciousness (Michalko, 2006). The difference between free association and forced relationship is also repeatedly noted (Fulmer, 1974; Van Gundy, 1998). Although the free association techniques allow users to choose association and stimuli freely, the forced relationship techniques require users to find connections between the creative task and certain stimuli.

One classification of IGTs is based on whether the technique preserves, stretches, or breaks the existing paradigms (McFadzean, 1998). However, this method appears to be a leap from techniques to outcomes. Paradigm modification depends on more than just the techniques: the people who use them and the problems at hand are at play as well. It seems unlikely that certain techniques consistently break paradigms, whereas some others always preserve paradigms. For example, brainstorming is named as a paradigm preserving technique, but it seems possible for people to come up with paradigm breaking ideas in brainstorming. Therefore, I argue that this categorization needs more empirical support or refinement.

To my best knowledge, Van Gundy's work (1998) is the only one that explicitly suggests a taxonomy of IGTs. On the basis of some of the criteria mentioned in the last row of Table 1, he developed a structure that may be used to systematically classify IGTs (Van Gundy, 1988). For example, he pro-

posed that group techniques can be divided into brainstorming and brainwriting subgroups, which mean verbal and silent ideation, respectively. Brainstorming techniques, or verbal techniques, can be further divided into structured and unstructured techniques. Structured techniques can be either free association techniques or forced relationship tech-niques.

However, the distinction between structured and unstructured techniques seems less useful because almost all techniques are structured techniques. I also contend that the difference between related and unrelated stimuli is not always clear: many stimuli can be remotely related to a focal problem, making the distinction very difficult. Most importantly, it is unclear how the taxonomy is connected to the theoretical and empirical studies on creativity.

The other classifications do not form a system. They only divide IGTs into several groups, without identifying subgroups. Nevertheless, they all provide some unique insight, for example, the grouping of checklists (Grube and Schmid, 2008) and changing and shifting perspective (Lau, Ng, and Lee, 2009). These insights are integrated in the forming of the new taxonomy.

Knoll and Horton (2011) classified IGTs into three groups: jumping, dumping, and pumping. This grouping is based on the search for ideas in associative memory (SIAM) model of idea generation (Nijstad and Stroebe, 2006). In this model, stimuli can activate knowledge in mind and the activated knowledge is processed into ideas. Jumping is about using unrelated stimuli to prompt ideas. Pumping is about focusing on specific aspects of a problem to facilitate ideation. Dumping is about challenging or abandoning existing assumptions or notions to find novel ways of thinking. Although this typology is grounded in a creativity theory, as mentioned by the authors, there are many techniques that do not fall into the categories. For example, it is unclear where brainwriting (Heslin, 2009) and mind mapping should be in the classification.

Other than these resources on classifications, there are two types of research that are relevant and important. The first type collects and analyzes the mechanisms in IGTs. Smith (1998) collected 50 "active ingredients" of IGTs, for example, decomposition, abstraction, fantasy, negation, remote stimuli, and nondisclosure.

The information is useful but seems less grounded in creativity theories. Another type of research identifies the attributes of ideation techniques, for example, interactive versus noninteractive, emotional or not, web-usability (Grube and Schmid, 2008), anonymous or not, collocated or distributed, and expression mode (speaking, writing, drawing) (Nagasundaram and Bostrom, 1994). Especially interesting is Grube and Schmidt's work (2008), which has tables listing attributes of 186 creativity techniques. Although it does not propose a systematic classification structure, the rich information is very valuable.

4 A new classification of IGT

4.1 Theoretical basis

In this section, some theories related to the motivation and cognition of creativity are discussed because of their potential to generate implications for IGTs. Amabile's componential theory of creativity argues that creativity has three components: task motivation (mainly intrinsic motivation), domain expertise, and creative skills (Amabile, 1983, 1996). IGTs typically do not improve users' domain expertise. Instead, IGTs can be useful in improving creative skills and potentially task motivation.

As mentioned by Smith (1998), some common strategies in increasing motivation are goal setting and competition. For example, one rule of brain-storming is to come up with many ideas or go for quantity. This can be considered as goal setting (Litchfield, 2008). Some techniques include the component of idea generation contest, which boosts motivation through competition. However, IGTs are typically focused on the cognitive aspect of creative work with motivational mechanisms as only small components. Consequently, even though I recom-mend considering motivational mechanisms in choosing IGT, these mechanisms are not used in the classification directly.

The component of creative skills in componential theory of creativity can be understood in the lens of cognitive theories of creativity. The search for ideas in associative memory model is a cognitive theory specifically focused on idea generation (Nijst-

ad and Stroebe, 2006). This model assumes that there are two memory systems in mind: long-term memory and working memory. Long-term memory, with unlimited capacity, is a highly interconnected network with many associations and categories. Working memory provides temporary storage and conduct conscious operations, such as recognition and decision making.

SIAM assumes that ideation is a repeated search process in the associative long-term memory. First, a search cue, such as a problem or stimulus, activates certain knowledge in the long-term memory. The activated knowledge is stored in working memory. Then working memory processes the activated knowledge, such as combine knowledge; forms new associations; and produces ideas.

SIAM indicates that people monitor their own ideation process so that failure to activate new and relevant knowledge or failure to generate ideas serves as a negative feedback that can potentially end the ideation. Relatedly, when people suspend judgment, as prescribed in the brainstorming rules, the self-monitoring is reduced so that more ideas can be generated.

SIAM implies that IGTs should potentially lead to new search cues or facilitate the function of working memory. The former can be done through introducing external stimuli or searching internal stimuli, for example, by analyzing a problem in different ways. The support for working memory may be done through facilitating different processing of knowledge, such as the visualization, organiza-tion, association, and combination of knowledge.

A recent theory about the processing of knowledge in creative problem solving is the explicit–implicit interaction (EII) theory (Helie and Sun, 2010). The EII theory assumes that there are two types of knowledge, explicit knowledge and implicit knowledge. Explicit knowledge, which is often symbolic, is easier to access and verbalize. The use of explicit knowledge requires more attentional resources. In contrast, implicit knowledge is relatively inaccessible, harder to verbalize, and more vague. Using implicit knowledge does not require much attentional resource.

Accordingly, there are two types of knowledge processing: explicit processing and implicit processing. Explicit processing involves some form of rule-based reasoning and is relatively exact. Implicit processing is associative and can be vague. EII argues that creative problem solving needs both explicit processing and implicit processing. Overemphasis on one of the processing types can be detrimental to creative performance. The implication of EII is that IGTs may be classified based on which type of knowledge processing is dominant.

The research on group creativity has identified many factors that influence idea generation in groups. Paulus (2000) argued that both social factors and cognitive factors are related to group creativity. Social factors include phenomena such as free riding and competition. Examples of cognitive factors include attention and priming. A major factor in group idea generation that draws much research attention is production blocking: the fact that only one group member can talk at a time. Production blocking is consistently shown to reduce the number of ideas generated per person in groups (Dennis and Valacich, 1993; Nijstad, Stroebe and Lodewijkx, 2003; Paulus and Yang, 2000).

Since production blocking has such an obvious effect on ideation productivity, it is worthwhile to consider whether production blocking is significant in an IGT. If group members take turn to speak, there is significant production blocking. In contrast, if group members write down ideas and share the writing silently, production blocking is minimized or eliminated. Therefore, categorizing group techniques as verbal or silent techniques captures this important aspect of production blocking.

In summary, some creativity theories are consulted in classifying IGTs. IGTs rarely influence domain knowledge but can influence motivation and creative skills in the componential theory of creativity. Creative skills are commonly cognitive skills. The cognitive theory SIAM implies that IGT may influence the generation of search cues that are used to probe long-term memory. Therefore, IGT may be classified based on whether they introduce external stimuli serving as search cues. In addition, SIAM implies that IGT may influence the knowledge processing by working memory.

Therefore, IGT may also be classified based on whether they emphasize explicit or implicit processing of knowledge. In group idea generation, production blocking is an important factor that affects idea quantity and group dynamics. Whether a technique is verbal or silent technique has major influence on production blocking and therefore ideation productivity and group interaction. This consideration can be a dimension in classifying group IGT.

4.2 A new taxonomy

On the basis of the theories mentioned earlier, a taxonomy of IGTs is developed below. Individual techniques are categorized based on whether they introduce external stimuli and whether they emphasize explicit or implicit processing of knowledge. Furthermore, in each category, subcategories are identified based on the stimuli or the processing. Many of these subcategories (such as *checklist*) are from the previous literature summarized in Table 1.

Group techniques are typically more focused on the exchange of ideas among group members than prescribing implicit or explicit knowledge processing. Therefore, group techniques are classified based on whether external stimuli are provided and whether people generate and share ideas verbally or silently.

1. **Individual techniques**
   - 1.1. External stimuli and explicit processing
     - 1.1.1. Checklist
     - 1.1.2. Innovation knowledge base
   - 1.2. External stimuli and implicit processing
     - 1.2.1. Change of perspective
     - 1.2.2. Change of problem
     - 1.2.3. Forced connection
     - 1.2.4. Provocation
   - 1.3. Internal stimuli and explicit processing
     - 1.3.1. Analytical – systematic techniques
   - 1.4. Internal stimuli and implicit processing
     - 1.4.1. Freewheeling techniques
     - 1.4.2. Intuitive techniques
     - 1.4.3. Displaying techniques
2. **Group techniques**
   - 2.1 Silent techniques with external stimuli
   - 2.2 Silent techniques with internal stimuli
   - 2.3 Verbal techniques with external stimuli
   - 2.4 Verbal techniques with internal stimuli

The explanation for each category and subcategory is given below.

1. **Individual techniques**

These techniques are designed to support individual creative work. They are sometimes used by groups as well.

1.1. External stimuli and explicit processing

Techniques in this category introduce some external stimuli into creative work and encourage rule-based explicit processing of knowledge.

1.1.1. Checklist

These techniques use a list of questions or explicit thinking strategies to facilitate idea generation. SCAMPER is the most typical example (Eberle, 1972).

1.1.2. Innovation knowledge base

Structured knowledge has been accumulated from the analysis of numerous innovations. The techniques in this type use such knowledge to help identify solutions to problems. Forty inventive principles in TRIZ (Teorya Resheniya Izobreatatelskikh Zadatch) is the most typical example (Savransky, 2000).

1.2 External stimuli and implicit processing

These techniques provide external stimuli but do not emphasize rule-based explicit processing of knowledge.

1.2.1. Change of perspective

This group of techniques seeks different perspectives toward the problem or its elements. The Napoleon technique (Higgins, 2005) is an example. Using this technique, a user may consider how Napoleon would solve the focal problem.

1.2.2. Change of problem

These techniques solve different problem(s) before tackling the real problem. There are few rules as to finding the solution to an alternative problem and how to use that solution. A good example is reversals (Van Gundy, 1988). Using this technique, a user

solves the opposite problem before solving the focal problem.

1.2.3. Forced connection

This group of techniques stimulates ideas by identifying similarities or connections between the problem and some other object or ideas. A good example is metaphors (Van Gundy, 1988). The technique does not provide clear rules to guide people in using metaphors. Searching for similarities or connections is largely an associative and implicit process.

1.2.4 Provocation

Provocation techniques stimulate ideation by identifying and challenging assumptions and preconceptions or considering counterfactual statements and the implications. A good example is reverse assumptions (Michalko, 2006). Although the "reverse" operation seems similar to explicit knowledge processing, the real creative part of the technique is to identify the implication of the reversal, which is largely implicit processing.

1.3 Internal stimuli and explicit processing

Techniques in this category do not focus on using external stimuli. Instead, they enable users to analyze the creative task and identify useful information by themselves. The identified information is then processed by certain rules such as combination. The only subcategory identified here is analytical–systematic techniques, and the possibility of additional subcategories is left open.

1.3.1 Analytical – systematic techniques

Techniques in this group are based on (systematic) analysis of a problem. They typically involve decomposition of a problem followed by further analysis and reassembly. Morphological analysis is the classic example.

1.4 Internal stimuli and implicit processing

Techniques in this category focus on information found internally and do not provide explicit rules in processing the information into ideas.

1.4.1 Freewheeling techniques

In freewheeling techniques, the choice of association and stimulus is free. These techniques do not explicitly stimulate imagination or subconscious processes. Free association (Van Gundy, 1988) is a typical example. In this technique, a user writes down a random word and a series of associations, all of which are then used to stimulate ideas.

1.4.2 Intuitive techniques

This set of techniques explicitly stimulates imagination or subconscious processes. Fantasy questions (Michalko, 2006) is an example. In this technique, a user imagines many "what if" scenarios to inspire ideas.

1.4.3 Displaying techniques

As the name suggests, this group of techniques stimulates ideation by displaying ideas, associations, attributes, or elements of the problem. Mind mapping is a classic example.

2. **Group techniques**

Group techniques are specifically developed for group usage. In choosing group techniques, the personalities and dynamics in the group could be the decisive factors.

2.1 Silent techniques with external stimuli

Silent techniques depend on silent ideation, which is usually expressed by writing or drawing. Techniques in this category use external stimuli to inspire ideas. Excursion (Van Gundy, 1988) is an example. In this technique, a facilitator guides group members to take an imagined excursion into some physical location that has nothing to do with the problem. The group members are then asked to silently generate ideas that are shared later.

2.2 Silent techniques with internal stimuli

In this category of silent techniques, no external stimuli are used. A good example is brainwriting pool (Van Gundy, 1988), which is a specific brainwriting technique. Each person writes down ideas and places them in the center of a table where a "pool" of ideas forms. Team members are free to pick up one or more of these ideas to inspire additional ideas.

2.3 Verbal techniques with external stimuli

In these techniques, people express and exchange ideas mainly through speaking. These techniques provide external stimuli to inspire new ideas. Gordon/Little is a good example (Gordon, 1961). In this technique, a facilitator introduces the general subject area and bit by bit reveals information about the focal problem. The group members are encouraged to discuss ideas along the way.

2.4 Verbal techniques with internal stimuli

In these techniques, people exchange ideas verbally without being exposed to external stimuli. Group brainstorming is an example.

A classification of 87 IGTs is presented in Table 2.

Table 2. The Classification of 87 IGTs (*Source:* Author' own research)

Individual or Group IGT	Categories of IGT	Specific Idea Generation Techniques
Individual IGT	1.1 External stimuli and explicit processing	1.1.1 Checklist: Phoenix checklist (Michalko, 2006); Product improvement checklist, SCAMPER (Higgins, 2005) 1.1.2 Innovation knowledge base: TRIZ (Savransky, 2000)
	1.2 External stimuli and implicit processing	1.2.1 Change of perspective: Fresh eye (Van Gundy, 1988), Talk to nonexperts (Michalko, 2006), The Napoleon technique (Higgins, 2005) 1.2.2 Change of problem: Make problem more abstract (Michalko, 2001), Reversals(Van Gundy, 1988) 1.2.3 Forced connection: Analogies, Attribute analogy chains, Bionics, Catalog, Circumrelation, Cliches, Proverbs and Maxims, Creative visualization, Focused-object, Metaphors, Modifier–noun associations, Nonlogical stimuli, Relational algorithms, Symbolic representations, Word diamond (Van Gundy, 1988); Random word (Michalko, 2006); Establish idea sources, Googlestorming, Organized random search, Picture stimulation (Higgins, 2005) 1.2.4 Provocation: Assumption reversals, Exaggerated objectives, Hypothetical situations (Van Gundy, 1988)
	1.3 Internal stimuli and explicit processing	1.3.1 Analytical–systematic techniques: Attribute listing, Listing, Heuristic ideation technique, Morphological analysis (Van Gundy, 1988); Back to the sun, Circle of opportunity, FCB (Foote, Cone and Belding Advertising) grid (Higgins, 2005); Cherry split, Force-field analysis (Michalko, 2006)
	1.4 Internal stimuli and implicit processing	1.4.1 Freewheeling techniques: Attribute association chains, Two words, Free association (Van Gundy, 1988); Future scenarios (Michalko, 2006); Relatedness (Higgins, 2005) 1.4.2 Intuitive techniques: Dali's technique, Dreamscape (Michalko, 2006); Examine it with the senses, Incubation, Visualization, What if …? (Higgins, 2005); Storywriting, Wishful thinking (Van Gundy, 1988) 1.4.3 Displaying techniques: Mind mapping (Higgins, 2005); Lotus blossom (Michalko, 2006)
Group IGT	2.1 Silent techniques with external stimuli	Excursion (Higgins, 2005)
	2.2 Silent techniques with internal stimuli	Brainsketching, Brainwriting pool, Collective notebook, Crawford slip writing, Gallery method, Method 6-3-5, Pin cards (Van Gundy, 1988); Delphi technique, Idea board, Online brainstorming, Nominal group technique (Higgins, 2005); Collaborative sketching (Shah et al. 2001)
	2.3 Verbal techniques with external stimuli	Battelle-Bildmappen-Brainwriting (BBB), Component detailing, Force-fit game, Gordon/Little, Greeting cards, Rolestorming, Sculptures, Semantic intuition, SIL method, Super heroes, Synectics (Van Gundy, 1988)
	2.4 Verbal techniques with internal stimuli	Classical brainstorming, Phillips 66, Story boards, Trigger method (Van Gundy, 1988); Creative imaging, Lion's den, NHK (Normal Human Epidermal Keratinocyte) method (Higgins, 2005)

4.3 Guiding the selection of IGT with the taxonomy

The taxonomy can be useful for anyone who wants to use IGTs to achieve creative outcome. It can be particularly relevant to creative professionals, facilitators of creative processes, managers of innovative projects, and people developing information systems to support creative work.

First and foremost, the use of IGTs should be informed by empirical studies. It is important to note that not every technique is equally tested and validated in the research literature. Among the more studied technique are brainstorming, brainwriting, and TRIZ. TRIZ has been shown to improve students' creativity in engineering problem solving (Chang et al., 2016) and to benefit creative work in practice (Ilevbare, Probert, and Phaal, 2013). Brown and Paulus (2002) suggested that although group brainstorming tends to generates fewer ideas than the same number of individuals brainstorming in isolation, there are ways to improve productivity in group brainstorming, such as exchanging ideas by computers and using heterogeneous groups. Their computer simulation further shows that brainstorming in a group can potentially lead to ideas that are less likely to result from individuals brainstorming alone. Heslin (2009) summarized that brainwriting potentially leads to more and better ideas than group brainstorming. The findings with regard to these commonly studied techniques should be considered in selecting IGTs.

Table 3. The Overall Guide for IGT Selection (*Source:* Author' own research)

Individual or group idea generation	Idea generation situation		IGT selection
Individual	Analysis or inspiration	Analysis	Explicit processing
		Inspiration	Implicit processing
	Need for breaking fixation	High	External stimuli
		Low	Internal stimuli
Group	Group size	Large	Silent techniques
		Small	Silent or verbal techniques
	Random variation or creative synthesis	Random Variation	Silent techniques
		Creative Synthesis	Verbal techniques
	Group members	Introverted	Silent techniques
		Extroverted	Silent or verbal techniques
	Need for breaking fixation	High	External stimuli
		Low	Internal stimuli

Many other IGTs are rarely tested by scientific studies. Therefore, it is premature to assume that all IGTs are as effective as expected. The suggestions for selecting IGTs presented below are connected to academic research when possible. But it is important to note the general lack of empirical research on many IGTs and to recognize additional research is needed to further develop these suggestions.

Second, it is worth noting some common tips for both individual work and group work. The componential theory of creativity (Amabile, 1983, 1996) indicates that creative work can be supported by motivational or cognitive mechanisms. There seems to be no IGTs that solely focus on motivation. However, it may be useful to consider using some motivational mechanisms, such as goal setting (e.g., setting a quantity goal in brainstorming, mentioned by Litchfield, 2008) and competition (as in Force-fit

game (Van Gundy, 1988). This is particularly important if the initial task motivation is not high.

As for the cognitive aspect of ideation, SIAM implies that there is a self-monitoring mechanism so that only good-enough ideas are expressed. In group work, people can also refrain from sharing ideas because of the fear of criticism. Reducing this self-monitoring, such as the "suspend judgment" rule in brainstorming, may facilitate fluent ideation. Next, the selection of individual and group techniques is discussed separately. The selection guide is summarized in Table 3.

4.4 Selecting individual techniques

In selecting individual IGT, a user needs to analyze the goals and situations that demand creative ideas. The first question is whether the user wants to have in-depth analysis of the creative task and obtain ideas in a more organized way or to search more randomly and use some inspiration (analysis versus inspiration). In the former case, those techniques using explicit processing of knowledge are more appropriate. For example, when the creative task is complex and includes multiple components or if people prefer structured thinking, using explicit processing techniques is better. For instance, following the product improvement checklist (Higgins, 2005) or force-field analysis (Michalko, 2006) can lead to ideas in a structured way. In general, explicit processing is more structured and exact, whereas implicit processing is more vague and flexible. If more flexibility or more randomness is needed for more diverse outcomes, implicit processing techniques can be useful. For example, intuitive techniques and forced connection can be particularly helpful (using internal and external stimuli, respectively).

The second question is whether the user wants to use external stimuli to bring in new perspectives. In other words, whether there is a strong need to break mental fixation. Although people can sometimes develop new perspectives without external stimulation, such stimulation can be particularly useful when people have spent long time on using internal stimuli and still do not obtain desirable creative outcome. The use of external stimuli can be either through explicit processing (such as TRIZ (Savransky, 2000) or through implicit processing (such as change of perspective). In contrast, when people are faced with a creative task for the first time, it is useful to analyze the problem itself and identify the different elements involved. In other words, it is useful to focus on internal stimuli first so that the problem is fully analyzed and understood. In this process, people can rely on explicit processing, such as decomposing the problem and reassembling later, as in analytical–systematic techniques, such as morphological analysis (Van Gundy, 1988). Alternatively, people can also use implicit processing, such as displaying techniques (such as mind mapping (Higgins, 2005) and freewheeling techniques (such as free association (Van Gundy, 1988)).

Sometimes people generate ideas to improve an existing product or idea, instead of starting from scratch. Two techniques are specifically designed for this type of situations: SCAMPER and product improvement checklist (Higgins, 2005). At times, it is important to visualize the relationship among ideas. Displaying techniques, such as mind mapping (Higgins, 2005) and lotus blossom (Michalko, 2006), are particularly useful for this purpose.

As the new taxonomy indicates, the two key attributes for an individual technique are whether external stimuli are provided and whether explicit or implicit processing is emphasized. Creative work can benefit from both internal and external stimuli, as well as explicit and implicit processing of knowledge. Therefore, I contend that, if possible, a reasonable approach is to try to balance the use of these different techniques to get the most benefits from IGTs.

Lastly, individual IGT can be used in groups as well. For example, each group member can use the individual technique, assumption reversals, on his or her own. In this type of situations, the suggestions for selecting individual techniques can also guide the group in selecting techniques.

4.5 Selecting group techniques

Similar to individual creative work, group creative work can benefit from both external and internal stimuli. In choosing group techniques, it is useful

to have people use internal stimuli first so that different aspects of the creative task are fully understood. Introducing external stimuli afterwards may expand thinking and bring new perspectives. In other words, when there is a strong need to break mental fixation, it is useful to use techniques with external stimuli.

Harvey (2014), as well as Chen and Adamson (2015), pointed out that two major components in group creativity are random variation and creative synthesis. Random variation can result from the diverse background, perspectives, and imagination of group members. Creative synthesis is the integration of group members' perspectives into a unique shared understanding. Verbal techniques allow people to gain attention of all group members and clarify, debate, or synthesize ideas. Therefore, I argue that verbal techniques tend to benefit creative synthesis. Relatedly, it has been shown that verbal brainstorming results in people conforming to each other's ideas (Kohn and Smith, 2011). In contrast, silent techniques allow people to ideate on their own, which tend to favor the exploration of diverse directions and perspectives, that is, random variation.

There are other differences between silent and verbal techniques. Silent techniques allow people to ideate by themselves without being interrupted and without the fear of criticism by others. Therefore, silent techniques are able to reduce production blocking, cognitive load, and evaluation apprehension (Paulus, 2000). In addition, social loafing (Paulus, 2000) may be reduced. In contrast, verbal techniques, especially used in large groups, could lead to high levels of production blocking and social loafing (Paulus, 2000). However, using verbal techniques might raise energy level and motivation because verbal communication could be more exciting than sharing ideas silently (e.g., on paper).

Accordingly, there are some situations in which using silent techniques is particularly appropriate: when divergence and diversity are desired, when group size is large, when group members are introverted and quiet, when some group members talk too much, when it is a virtual group such that verbal discussion is less convenient, when anonymity is desirable, and when idea quantity is a major goal (so that production blocking is very undesirable). When much clarification, debate, or idea synthesis is needed or when the group needs some conversation to boost up energy, verbal techniques are more desirable. In practice, because both silent and verbal techniques have important benefits, I argue that it is preferable to use both types of techniques.

Lastly, it has been shown repeatedly that combining individual work and group work can lead to more creative outcome (Girotra, Terwiesch, and Ulrich, 2010; Korde and Paulus, 2017). Therefore, if possible, a group should use both individual techniques (in individual sessions) and group techniques.

5 Implications for future research

There are certainly ways to improve the current classification. It would be useful to include more IGTs, ideally all of them, into the classification system. When adding more IGTs, it is possible that more subcategories can be identified. Identifying such new subcategories may improve our understanding of IGTs and even creativity theories.

Another way to improve the taxonomy is to connect to additional creativity theories. As an example, the 4-P's theory of creativity indicates that creativity has four aspects: person, process, product, and press (Rhodes, 1961). The current taxonomy is focused on the process aspect. Classifying IGTs with regard to the kind of product they produce (such as visual versus verbal outcome) seems possible. Matching certain personal characteristics with certain IGTs might also lead to further clues for classification. Cognitive network model (CNM) of creativity (Santanen, Briggs, and de Vreede, 2004) is another important theory that may be relevant. CNM has similar assumptions as SIAM, for example, the existence of working memory and long-term memory and the steps of knowledge activation and knowledge processing in ideation. A major difference is that CNM emphasizes the role of stimuli diversity and its impact on cognitive load and idea originality. It might be possible to classify IGTs in terms of the diversity of stimuli provided and whether measures are available to reduce cognitive load.

The taxonomy is more than just a result deduced from creativity theories; it also leads to many questions that might inspire theories. What are common types of stimuli to be used in creative work? What are common types of explicit or implicit processing? What are common modes of silent and verbal interaction among people? How do all these factors interact? Management researchers have studied the relationship between creativity and personality traits (such as Big Five), thinking styles (such as intuitive versus systematic), knowledge level, job complexity, team structure, and composition (Anderson, Potocnik, and Zhou, 2014). However, the studies on the interactions among these factors and different IGTs seem rare (an exception being Garfield, Taylor, Dennis, and Satzinger, 2001). Theoretical analysis and empirical testing of these research questions can improve our understanding of the multifaceted phenomenon of creativity. In this process, additional subcategories may be found to enrich the taxonomy.

A related research stream is the evaluation of IGTs. Even though so many IGTs have been proposed and used in practice, not many techniques have drawn continuous research attention (brainstorming being an exception). Particularly important is to assess and compare the effect of using various IGTs. Garfield et al. (2001) found that an intuitive creativity technique (guided fantasy) led to more paradigm-modifying ideas than an analytical technique (force-field analysis). Herrmann and Felfe (2014) found that provocation technique led to higher creativity than brainwriting. Hender, et al. (2002) concluded that using analogies in group support systems led to fewer but more creative ideas than electronic brainstorming. These studies provide important insights in comparing different IGTs. Using the new taxonomy, the comparison among IGTs can be done in a more systematic way. Different categories and subcategories of IGTs can be compared. Techniques within a subcategory can also be compared, for example, different checklists can be contrasted. More theorizing about the match between situations and techniques can be developed and tested. Ideally, situations can be matched with appropriate subcategories of IGTs and the IGTs may even be ranked in usefulness for a certain situation. Similarly, it is possible that certain subcategories of IGTs work well with certain types of people or group. Such match can be tested and lead to further practical guidance on the use of IGTs.

Another research topic is the adoption of creativity techniques in practice. Although some techniques, such as brainstorming, have been extensively studied in lab settings, the adoption and use of creativity techniques in the real world is not well understood (Sutton and Hargodon, 1996; Wang, 2014). The taxonomy may help researchers systematize the study of the antecedents and consequences of the use of different types of IGT.

Lastly, it is important to explore the use of the taxonomy in the digital age in which machines are continuously getting smarter. Combining the power of machines and humans to create value is a key competency in the modern economy (Brynjolfsson and McAfee, 2012). The taxonomy leads to research questions about group support systems (Briggs, de Vreede, and Nunamaker, 2003) and creativity support systems, that is, information systems that support creative work (Althuizen and Reichel, 2016; Wang and Nickerson, 2017). A key question is how can IS support different types of IGTs? For example, it is useful to explore how IS can support the search of external and internal stimuli to assist the use of IGTs. In addition, various IGTs may be related to collaboration engineering, an approach using collaborative technologies and processes to support group tasks (Briggs et al., 2003). A partic-ular relevant concept in collaboration engineering is thinkLet, a standardized facilitation technique considered as a building block in the design of collaboration processes (Briggs, et al., 2003; Bittner and Leimeister, 2014). The IGTs within a subcategory in the taxonomy may be abstracted as one or multiple related thinkLets. A set of categorized thinkLets for creative collaboration may be developed according to the taxonomy. In this way, the various IGTs may be translated into IS-supported and repeatable modules that can enhance group creative work.

Moreover, I maintain that IS are more than just a tool that facilitate the use of existing IGTs: they can give birth to brand new tools that potentially revolutionize creative work. For example, IGTs do not provide

domain knowledge or a long-term memory, whereas IS can supply a searchable knowledge base, essentially serving as an external long-term memory. The explicit rule-based processing of knowledge in creative work may be facilitated or automatized in creativity support systems. New IS techniques might be developed to even support and automatize implicit knowledge processing such as associations. When both explicit and implicit knowledge processing are supported with computational power, humans' ideation ability might be dramatically enhanced. These developments need the guidance of theories in creativity, group process, team manage-ment, and information systems. Such developments can also benefit from the new taxonomy proposed, as well as the specific IGTs within the taxonomy. In addition, IS are used to connect people worldwide, which facilitates crowd-sourcing innova-tion and outsourcing innovative tasks to an unde-fined group of people through an open call (Afuah and Tucci, 2012; Howe, 2006; Wang, Nickerson and Sakamoto, 2018; Wang, Wang, and Tao, 2017). Even though the IGTs reviewed here are not specifically designed for crowds, they can potentially be used in crowd-sourcing. For example, some researchers instructed crowd workers to identify analogy candidates or to ideate through analogy (Hope, Chan, Kittur, and Shahaf, 2017; Yu, Kittur, and Kraut 2014). The new taxonomy of IGTs can guide a systematic exploration of using IGTs in crowdsourcing and potentially lead to various new crowd ideation techniques. These efforts may improve the effective-ness of crowdsourcing innovation.

6 Conclusion

It is useful to develop a classification of IGTs to facilitate their selection. The existing categoriza-tions of IGTs are rarely systematic and theory based. This article uses three creativity theories to guide the development of a taxonomy of IGTs and classifies 87 IGTs according to the taxonomy. This clas-sification enables the selection of IGTs in a more systematic way. It also leads to some future research topics that may further inform our understanding and practice of creativity.

7 References

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