

Solo ideation in digital tools

*Uncovering the unmet need for facilitating
solo ideation in commercially available,
digital creativity support tools.*

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Abstract

This thesis investigates the role of *solo ideation* in *digital creativity support tools*. The purpose is to uncover the unmet needs for facilitating solo ideation in commercially available digital creativity support tools (CSTs).

In this work, terminology in the field of digital CSTs is defined and discussed; notably the terms *solo ideation*, *creativity* and *method, technique & tool*. This work reveals that there is no apparent consensus on terminology in the field. Definitions and models for understanding the terms in the context of digital CSTs are then proposed.

The thesis presents seven design aspects for evaluating *an ideal digital CST for solo ideation*: (1) be digital reliant (2) stimulate pattern recognition (3) avoid Mode 2 of thought (4) be usable by a single user (5) offer external information (6) offer relevant information (7) offer continuous ideation. The design aspects are developed by specifying, analyzing and discussing work in the field of creativity, digital CSTs and ideation.

The design aspects are then used to review the field of commercially available digital CST, to investigate what role solo ideation holds in those. The review reveals that the most popular tools are *ideation management tools*, focused on collaborative work and ill-suited for solo ideation. I found virtually no tools to facilitate solo ideation in a satisfactory manner. The thesis concludes with the finding that solo ideation is not sufficiently supported in commercially available digital CSTs.

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Chapter 1:

Introduction

The field of digital creativity support tools

Digital *creativity support tools* (CST) shows to be both popular and beneficial to generating ideas (Jonson 2005; Faste et al. 2013; Frich et al. 2018; Bae et al 2020; Taylor & Jordan 2020, 2021). In 2007 Tomás Dorta showed a lack of digital CST usage and research, but in recent years both the academic and commercial field of digital CSTs has grown exponentially, cementing the field as an emerging one worthy of investigation and research. (Dorta 2007; Frich et al. 2018; Maiden et al. 2019; Bae et al 2020; Taylor 2017, 2018, 2019; Taylor & Jordan 2020, 2021)

Research suggests that *generating ideas alone is usually more effective than doing so together*. (Osborne 1953; Taylor et al. 1958; Diehl & Stroebe 1987; Mullen et al. 1991; Furnham 2000; Nijstad et al. 2007; Girotra et al. 2009). Frich et al (2019) showed that the field of digital CSTs is mostly concerned with *collaborative* creativity, rather than *solo creativity*.

Furthermore, most studies on digital CSTs are human-centric: investigating broader human behavior through usage of tools, rather than the impact of the tools on human behavior. (Frich et al 2019) This translates into a body of research that is somewhat unconcerned with the impact of tools and technologies. There is however some research covering the tool-centric approach; and it shows that CSTs can yield beneficial results for a designer, if utilizing technology in ways analog tools never feasibly could. (Faste et al. 2013; Chen 2019; Bae et al. 2020)

In essence, *thinking up* ideas alone is beneficial, and digital CSTs is an *emerging, yet commercially widespread field*, worthy of development and research. This poses the question of whether or not existing commercially available digital CSTs are suitable for solo users to be *thinking up ideas*. This pondering, is formulated in the follow research question for the thesis:

How well is solo ideation supported in commercially available digital creativity support tools?

The terminology introduced in the research question; notably *solo ideation*, *creativity* and *tools*, will be further defined and discussed in the following chapters.

Thesis structure

To answer the research question, I must understand, condense and analyze findings within creativity, ideation and digital CSTs. That work results in a list of seven design aspects to be

used for evaluating existing commercially available digital CSTs. The following is how the work is presented.

- Firstly, I clear up the terminology of the field, defining the concepts *creativity, ideation, tool and solo ideation* in the context of digital CSTs and this thesis. During this work, I propose my model of understanding the core concepts *Methods, Techniques and Tools*.
- Next, I work out the design aspects for evaluating existing digital CSTs in regards to solo ideation. I do this by understanding, analyzing and discussing the concepts within the field of digital CSTs and solo ideation. This work is done in a separate chapter for each aspect, resulting in seven aspects which can be used for review of existing digital CSTs.
- Then, I reap the benefits of having created the design aspects by reviewing the field of existing, commercially available digital CSTs for ideation. This serves as a mapping of existing digital CSTs and their ability to facilitate solo ideation, while opening up opportunities for discussing the effect of implementation's implications for the various design aspects.

The work is then discussed, and concluded upon. Happy reading!

Chapter 2:

Terminology in the field of digital CSTs

A side effect of the emerging nature of the field is the lack of common terminology. (Dorta 2007; Frich et al. 2018)

“...without a structured overview of the key concerns, concepts, and approaches at work, this diversity also renders the field opaque, and it makes it challenging for academics to engage in fruitful discussions and compare findings across studies.”

- Frich et al. 2018, page 1235

To understand the premise and purpose of the thesis, there is a need to clarify terminology throughout the field. Perusing the research question: *“How well is solo ideation supported in commercially available digital creativity support tools?”* Some core concepts stand out as not clearly defined; notably *creativity, ideation* and *tools*. The following chapter reviews existing terminology of these three core concepts, in the context of digital CSTs. Further, this chapter describes *solo ideation versus collaborative ideation* and the terms of *divergent- and convergent thinking*.

Looking to utilize any terms, one should specify terms to the context of its use. (Couger 1996). The intention of this work is to propose a well defined vocabulary, as a common understanding of the terminology in the field would be of benefit in this thesis - and the field of digital CSTs in general. (Couger 1996; Dorta 2007; Sauberer 2011; Frich 2019)

Creativity

Frich et al. (2018) identifies a trend in which researchers doing research on creative aspects of HCI (*human computer interaction*) omit defining creativity. In recent years, 2011-2015, 78% of relevant papers concerning creativity in digital mediums omitted defining creativity in any way. I hope to avoid contributing to this statistic by making it clear in what sense, a tool described as a digital *creativity* support tool, should define creativity.

Creativity is a broad term, and vague in nature (Newell et al. 1958). Looking to the dictionaries, we see the necessity for further definition as they are not in agreement, on what *Creativity* (the noun) is:

Den Danske Ordbog the ability to come up with new ideas and express them (in a imaginative or artistic way)

Cambridge Dictionary the ability to produce or use original and unusual ideas

Merriam-Webster the skill and imagination to create new things

Oxford Learner's Dictionary the use of skill and imagination to produce something new or to produce art

Collins Dictionary the ability to transcend traditional ideas, rules, patterns, relationships, or the like, and to create meaningful new ideas, forms, methods, interpretations, etc.

(Last retrieved August 2022)

Common for most, is that they combine the *coming up with ideas* together with some form of *production, creation or expression* of said ideas. While creativity is described as a skill, the separation of *coming up with* and *expressing* arguably means *creativity to be a process*, as there are two separate, inherent phases. As Couger (1996) argues; creativity should be specified within the context of use. The following is an exploration and discussion of different uses of the terms *creativity, creative* and *creative thinking*, in the field of creativity- methods, techniques and tools.

Coughlan et al. writes about design tools for creative tasks, similar to the context of this thesis. The view of creativity in the article is summed as “... a process resulting in outcomes that hold some form of both novelty and value” (Coughlan 2006, page 155) The notions of creativity as a process, and the outcome being novel are in agreement with the previous from the dictionaries. But another notion is added in the context: value.

J. D. Couger's definition is not far off from Coughlan's. Couger occupies himself in the context of improving Informational Systems. To be classified as *creative*, an improvement had to be *new or unique and have utility or value*. (Couger 1989, p. 5)

I think this notion of value should be specified further: A designer comes up with a novel idea of a certain product, it's original and new, yet no one wants to buy it, no one wants to develop it further, no one wants to describe or research it, in fact, no one wants anything to do with it after the designer finishes. It has seemingly no value - Is it not creativity that created the product then? One might argue that because the designer furthers their skill, while developing, there is some value in that - but if we acknowledge the process itself as a valuable outcome, the point of value is moot altogether. On the other hand, if we do not require the outcome to have value, but only novelty, the bar for creativity seems low, and any expressed thought of imaginative nature is then creativity. I tend to agree with Coughlan and Gouger, that creativity needs value or utility. As I see it, the non-valuable product is a product of imagination, but not necessarily creativity. This is an argument for creativity support, to define some standard for which to measure value against.

Another term to throw in the mix is Creative Thinking.

Carol Goman, author of *Creative Thinking in Business*, argues creativity to be “*Bringing in an idea to existence, that is new to you*” while she defines Creative Thinking as “*An innate talent that you were born with and a set of skills that can be learned, developed and used in daily problem solving.*” (Goman 1989, page 11) Creativity, the noun, in her definition allows for hedonistic or artistic motives - and pure imaginary products without value. Creative Thinking does not, as it is aimed at problem-solving and is seen as a talent and skill. She is not the only person to distinguish between creativity and creative thinking.

J. Rawlinson wrote in his book that Creative Thinking is: *To put things or ideas in connections with one another, which previously has been without common connection.*

Again, looking a lot like imagination and novelty, and not a lot about expression or value. This means *anything* connected for the first time, is now a creative output. This seems to be describing imagination - and not the full process of creativity.

John Adair classifies a *Creative Thinker* as a person who “*Has the power or quality to produce new ideas, especially ones not known to have existed*” (Adair 1996 page 13) This specifies an outcome of a skill; so if any process at all, within a person's thoughts, produces a *new idea* - it is Creative Thinking.

Newell, Shaw & Simon, Carnegie Institute of Technology, writes: “*Thus, creative activity appears simply to be a special class of problem-solving ...*” (Newell et al. 1958, page 5). I view the definitions of both Goman's Creative Thinking and Newell, Shaw and Simon's Creative Activity to convey creative output to hold value. If something solves a problem; it holds value - furthering the argument for creativity to contain *value* in its definition.

Lene Sørensen offers the following: “*Creativity is the ability to challenge assumptions, break boundaries, recognise patterns, see in new ways, make new connections, take risks, and seize upon chance when dealing with a problem*” (Sørensen, 2006). This view of creativity breaks it down as *an ability to do seven distinct tasks in regards to a problem*. She further writes “*In few words, creativity is an intuitive process for discovery that sometimes ends in a product, a process, an idea or just a new experience*” - this description shifts focus from the seven-tasks-process for dealing with a problem, to an intuition based process for discovery.

Clausen & Borch argue that any product of creativity is both *new and useful*. [Translated by author from: *Nyt & Nyttigt*] (Borch & Clausen 1996) They add that the definition leaves a question on who gets to decide what is new and useful? Their opinion is that the owner of the problem, the product aims to solve, gets to decide. This is easy to comprehend in a simple setting - a product to solve a practical issue. But what about a product of art - the observer that grants satisfaction upon viewing, is it then a problem of the observer not being satisfied previously, the product aims to solve? A piece of amusing art, such as depicted in fig 01, one could still view as creative.



*Fig 01, art by Christoph Niemann.
(Christophniemann.com ; retrieved aug 2022)*

The piece shown combines common *things* in a new way in an *expression* of mildly amusing art. I would argue it does not solve a *problem*, yet still holds value. It is *useful* to the observer who is amused. This poses a question of context for my thesis - is the creativity I aim to support with the digital *creativity support tool*, aimed at problem solving? Clausen & Borch's

definition is in the context of applied creativity in business, which is commonly aimed at problem solving, and not creating a piece of amusing art.

With that in mind, one could argue that I agree with Rawlinson's definition: "*To put things or ideas in connections with one another, which previously has been without common connection*" but I might add a "... *that makes sense*" in the end, as to express the need for some form of judgment of the outcome. Without judgment, or *sensemaking*, I argue that the outcome is merely imagination.

Creativity defined

Looking to the dictionaries again, comparing to the *Creativity* and *Creative Thinking* definitions we see the *expression* part of creativity is often left out. I attribute this to the *expression* part being dependent on a practical, specific skill, such as writing, drawing, calculating, talking, photoshopping, modeling etc. to translate ideas from abstract to specific - and thus separated from Creative Thinking.

My efforts in defining creativity shows the presented definitions to reveal a discrepancy in usage of the term creativity, sometimes even within the same article and book. I must then decide how the term is suited for the context of my work, and define it as such. Much of the discussed literature in the context of Creativity Support occupies themselves with problem solving as a defining trait of creativity.

My work reveals that there is no obvious consensus on creativity in the context of CST, but there is a prevalent notion of necessity to formalize and support creativity in regards to problem solve.

In this thesis I use the following terminology for creativity in context of digital CST:

A problem solving skill, expressed through a process, where ideas of novelty and value is thought up and expressed

Ideation

Once, the prevalent notion of *thinking up* ideas was to have *lightbulb-over-the-head* ideas; Aha!-moments that the designer wanders into seemingly at random. (Couger 1996) This has since been de-mystified and instead, ideas are described to occur as the brain defocuses from the world around it - granting the cognitive space to create new arrangements, combination or adaptations of existing information (Rawlinson 1981; Buzan 1993; De Bono 1995; Couger 1996; Hainsworth 2010; Goldschmidt 2016).

Formalizing idea generating, is the aforementioned ideation, where even small and simple steps towards some sort of guidance of thought, can net positive results. (Belski et al. 2014). It's a skill to be honed and systematized by designers. (Hainsworth, 2010). And while *Ideation* is not agreed upon terminology, it commonly represents some form of generating more information in a creative/design process (Kimbell 2011; Jen 2017). Creative process and design process are used interchangeably. While it might be arguable that *to design* is to

make decisions, and to be creative is to think up and express ideas of novelty and value to solve a problem, the term design is used somewhat interchangeably in regards to creative processes, as evident in fig 02. Hence I argue that any design process reflects a creative process, and the terminology is a matter of perspective, rather than content.

So while there is ambiguity on what ideation means, different practitioners and theorists in the field of design create models for how and when information is generated through a creative process. (Fig 02).

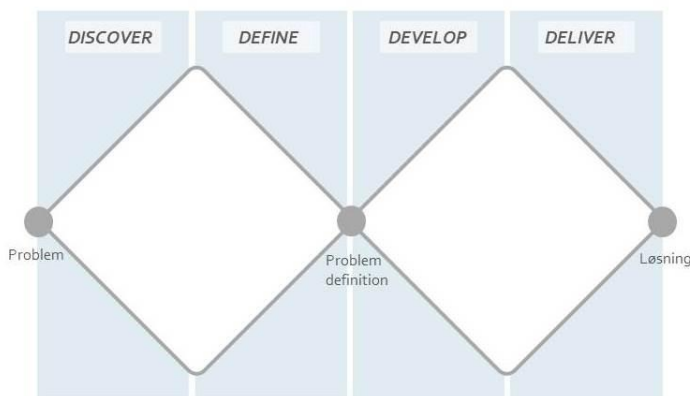


Fig 02a: *Double Diamond*, developed by The UK Design Council (Design Council, 2005) Graphic by Copenhagen University.

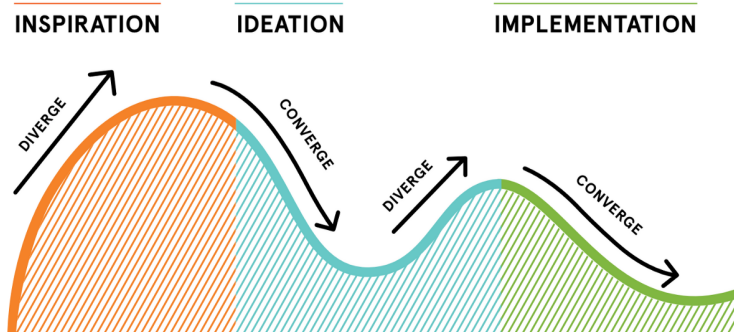


Fig 02b: *The Design Process* (graphic by IDEO.org, Scott, 2017)

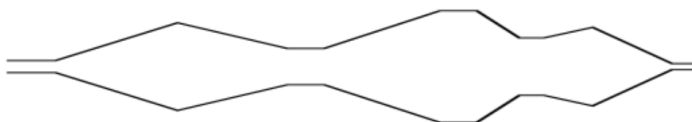


Fig 02c: *A Creative Process* (Borch & Clausen 1996)

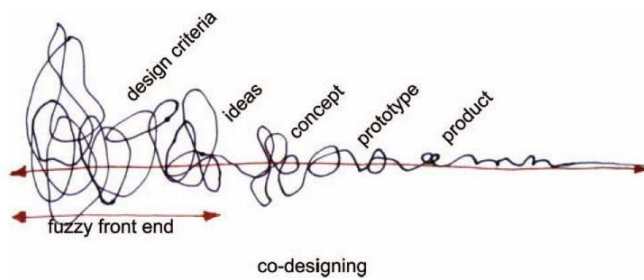


Fig 02d: *The fuzzy front end in design process*
(Sanders and Stappers 2008)

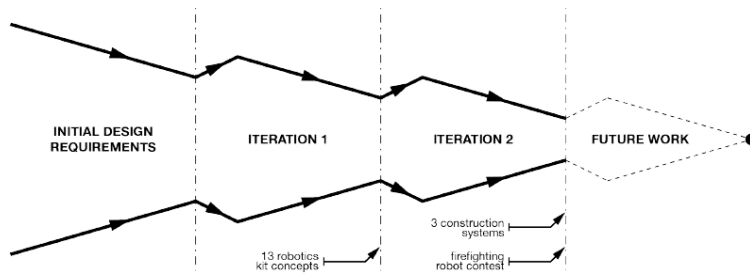


Fig 02e *Design Funnel*
(Adapted from Buxton 2010, p. 148 & Pugh 1991, p. 75 - by Vandevelde et al. 2015)

DESIGN PROCESS PHASES

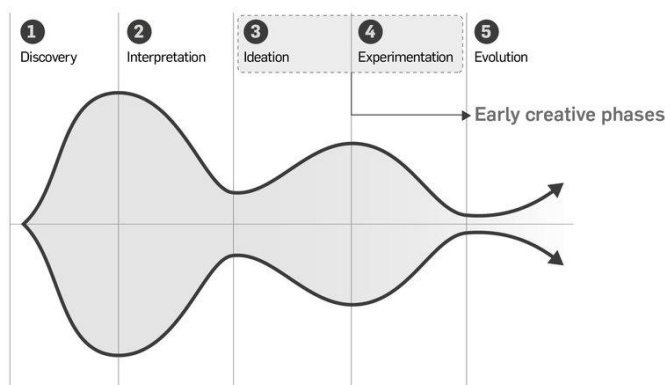


Fig 02f: *Design process phases* based on Design Thinking process for educators
(Torreblanca et al. 2019)

Reviewing the models, a common way of practicing, modeling and visualizing a creative process is with an X axis describing time, and a Y axis describing quantity of information in the proces, in some way. While not explicit in the models, the shift in the Y axis shows a difference *in the quantity of information*, as evident in their use and descriptions. (Design Council 2005; Scott 2017; Borch & Clausen 1996; Sanders & Stappers 2008; Vandevelde et al. 2015; IDEO & Riverdale, 2012; Torreblanca et al. 2019).

This means that when a model expands/ascends along the Y axis, the quantity of information increases. This phase, of increasing the quantity of information, is sometimes described as *ideation*, as seen in fig 02f. When an *evaluation & selection* process happens, the model will contract/descend, correlating to the quantity of information. In fig 02b, this phase, of decreasing the quantity of information, is also contained in the term *ideation*. I believe however, ideation is covering the space of where one thinks up ideas, in a structured and formalized manner.

In this thesis my definition is as follows:

Ideation is any formalized process to facilitate thinking up ideas.

Methods, Techniques & Tools

Terms like *tool*, *technique*, *process*, *method* and *methodology* are used somewhat interchangeably. (Kohls 2012; Furnham 2000; Osborne 1958; Jonson 2005; Naes et al. 2002; Rawlinson 1981). While many might not have heard of creative technique, method or tool in a sense of that terminology, they might have heard of some of the classics: The double diamond by UK Design Council (Ball 2019), sketching and storyboarding as laid out by Schön and Tversky respectively (Jonson 2005) or a mind map that visually stimulates the user's pattern recognition and associations (Michalko 2001) - or the even more popular Brainstorm (Osborn 1985) But what differentiates method, technique and tool?

Efforts have been made in recent years to clean up the vocabulary of the field of design process' (Löwgren & Stolterman 2004; Biskjær et al. 2017).

I find the framework proposed by **Biskjær et al.** flawed - as described by themselves in the paper:

“Occasionally, [in their own paper red.] you hear the term ‘creativity tools’, but often interchangeably with ‘creativity methods’ or ‘creativity techniques.’”

- Biskjær et al., 2017, p. 843

Another proposal of terminology is from **Löwgren & Stolterman** in 2004:

“Simply put, a method refers to a description of a way of working or a recipe for action. A method is always based on a specific purpose and specific values, and it translates them into an actable procedure. A technique is smaller in scope and ambition than a method and is frequently related to a particular form of expression or execution, as in the visual arts where pencil and charcoal can be categorized as techniques. A method may comprise several steps to be carried out in different techniques, or allow for the choice of different techniques in accomplishing a certain outcome“

- Löwgren & Stolterman, 2004, p. 62

This definition does not satisfy the needs of this thesis either. With such a leap from a method to a technique; method being overly abstract in form - and technique being hyper specific and practical. In my opinion it leaves a gap somewhere in the middle.

Their *method* is described as a *recipe for action*. If we stay in a *recipe* analogy - and the *method* is the general abstraction of *how to make a cake*. It's the step-by-step collection of steps to follow to end up with a *cake*. The method can be considered as follows: *nothing* -> step -> step -> step -> a *cake*.

One of the steps towards a finished cake, might be to *stir some ingredients together*. For that you would probably need a bowl and a spoon - or a whisk of some sort. This seemingly trivial example reveals three layers of the process:

Baking a cake

Stirring

Bowl & spoon

In Löwgren & Stolterman definition, the bowl and spoon would be categorized as *techniques*. But in my understanding, I argue that *stirring* is the technique, not the bowl, nor the spoon; those are the tools.

The *method* term presented by Löwgren & Stolterman can be disassembled into three inherent characteristics:

- 1) A way of working or recipe for action
- 2) Based on specific purpose and specific values
- 3) Translates into an actable procedure.

I think the definitions are a little vague, and can be interpreted multiple ways. If we accept this as sufficient description of a collection of subgoals, that theoretically should output a desired outcome, I would agree with this terminology. But one could interpret it another way; I don't view the *method* to *have to have* an actionable procedure. Instead, it could offer subgoals, which can then be fulfilled by a multitude of actionable procedures. That said, a method *can* have inherent actionable procedures, such a *stirring* in *baking a cake*, or more design related - the method prototyping that affords some sort of refinement over iterations by making, inherently and holds some noninterchangeable techniques for *making*. But methods such as the iterative process of *Design Thinking*, does not specify any techniques, only subgoals. (Dam & Siang 2022) This lends itself to the question of method being akin to *process* and I tend to agree - yet I view process as a term, for the chronological chain of events, and as such not of significant value in this context.

The baking example will then be divide as such:

Method	<i>Baking a cake</i>		
Technique	<i>Stirring</i>		<i>Other techniques</i>
Tool	<i>Bowl</i>	<i>Spoon</i>	<i>Other tools</i>

With this I show the need for distinction on the artifact and the practical appliance of the artifact. Let's stick to the charcoal for the next example of making technique and tool clear concepts.

Löwgren & Stolterman leave out *how* to use the charcoal. I think that charcoal can be applied with various techniques - one might *draw* with it, in a *sketching* technique. But one might also gather loads of charcoal, and build a model from charcoal. Or, maybe one uses

the charcoal to *throw at a canvas* to give a great effect of visual impact, arguably a technique to create quasi-random, jackson-pollock-lookalike patterns of chaotic impact. The examples should make it obvious charcoal is the artifact that is applied to fulfill the needs by the abstract goals of the techniques. Substitute the charcoal for watercolor, and the outcome of sketching, modeling and the chaotic jackson-pollock techniques will have different outcomes. I will propose then, contrary to Löwgren & Stolterman, that charcoal is not a technique. The technique is instead the way in which the tool is applied, with a goal in mind.

Sanders et al. (2010), proposes the following, more categorical definitions:

- *Tools = the material components that are used in PD [Participatory design] activities.*
- *Toolkit = a collection of tools that are used in combination to serve a specific purpose.*
- *Technique = Technique describes how the tools and toolkits are put into action. For example, many different techniques can be used with a deck of image cards. They can be sorted, categorized, prioritized, used to make a collage, tell a story and/or used to spark conversations.*
- *Method = a method is a combination of tools, toolkits, techniques and/or games that are strategically put together to address defined goals within the research plan.*
- *Approach = the approach describes the overall mindset with which the research plan is to be conducted. (Sanders et al. 2010)*

This seems more closely related to what I'm trying to convey with my definitions of the terminology. In the context of this thesis however, I find "*Approach*" redundant as it seems a matter of implementation and practice, not of theory. The separation of tool and toolkit further seems unnecessary, as the purpose for defining if something is a tool or technique, is to be able to investigate the impact of said tool on the technique or vice versa. Whether or not the tool is a part of a collection of tools commonly used together seems not to matter in that regard.

My discussion reveals that a change in either technique or tool, will inherently impact the results. The conclusion for this, is that the tools we chose for any given task, does matter. I have chosen to exemplify method, technique and tools in action.

Examples of methods, techniques & tools, in action

Example A of method, technique and tools in action:

A kayaking club is in need of a new logo. A team of 8 people volunteer to participate in a creative workshop session to create their new logo.

The facilitator wants to get as many ideas as possible, and then select the best ones. First, the group's goal is to get as many ideas as possible. Then, these ideas must then be judged and selected. To facilitate this, each team member gets 20 minutes, on their own, to draw as many proposals as possible on a piece of A3. The participants each find a place in the clubhouse to sit alone and draw. Afterwards, in a meeting room, the team members are instructed to send their A3 with proposals on, to the person next to them. When they receive a paper, they put a ' + ' mark next to logos they like, a ' - ' next to the ones they dislike and no mark at all if they're indifferent. After 30 seconds, they pass the paper on to the next participant. This continues until all participants have seen all of the proposals and scored them. The team leader has set a threshold of a score of five or more. This means, any proposal with an aggregated score of five or more is now selected, and the rest is discarded. The participants now have a set of logos to continue working on in a future workshop.

In this example, the method is a method of solo divergence and collaborative convergence - a tried and true method with the purpose of a few good ideas as desired outcome. It is ideation, followed by a judicial phase in the end. The method is facilitated by firstly a timed sketching technique for ideation, then a voting technique. The tools to facilitate sketching are the pen and A3 paper - and the voting technique is facilitated not only by pen and paper, but also the meeting room as the participant will be influenced by the presence of each other, the order in which they sit etc.

Example B of method, technique and tools in action:

A kayaking club is in need of a new logo. A team of 8 people volunteer to participate in a creative workshop session to create their new logo.

The facilitator wants the group to create a common understanding of the kayaking club, to then come up with the logo together. First, the facilitator asks the participants what they think of, when they think of the club. The facilitator condenses the thoughts of the participants into buzzwords they place on the whiteboard. When this is done, the whiteboard is filled with buzzwords, and arrows depicting relations between each. The facilitator asks each member to go into pairs, and submit a logo proposal and hand it in. After which they now have four logo proposals on the board. The facilitator writes four words beneath each of the logos: "Positives: Intriguing: Negatives: Concerning:". Now the participants must discuss each logo, in regards to the four words below. The facilitator writes down key aspects from the conversations on the board to each logo and word. Finally, the facilitator asks the participants to vote on what logos they want to keep working on. The facilitator points to a logo, and the participants raise their hands if they want to vote for the logo. The two logos with the most votes are then selected to be the iterations in which to work on, in the next workshop.

In this example, the method is a method of emphasis, divergence and then convergence. The emphasis is to establish a common understanding in the participant. The technique to

facilitate the emphasizing is a Brainstorm¹ of core concepts related to their club. Then, there is a technique of the collaborative creation of a logo in pairs. This in itself is a creative micro-cosmos, where each pair has to think up, express and judge an idea for a logo. The logos are then judged with the PINC Filter technique, and finally an open voting session on which logos should be selected.

The examples can be presented as such:

	Example A	Example B
Method	Diverge & converge	Emphasize, diverge & converge
Techniques	Individual sketching, on-paper-voting	Brainstorm, collaborative creation, PINC filter & hand-raise-voting
Tool	A3 paper, pen, meeting room	Post-ITs, pen, whiteboard, paper, meeting room
Expected Output	A few good ideas	A few good ideas

In **example A**, the individual has the most agency: There is no input from others, no social bias or dominant presence to impact the participants ability *thinking up ideas*. There is not any open discussion, and little power lies with the facilitator. The voting is semi-collaborative, as the participants can see each other and are aware of who's done which sketching and what logos has been voted for beforehand on their papers - but there is no apparent social discussion or discourse surrounding the work; hence semi-collaborative.

In **example B**, there is more agency to the collective as there is no technique for solo participants. In this process the facilitator holds hidden power, as they are the one with the pen at the whiteboard, deciding what words are written down and visualized; hence is the gatekeeper of the common understanding. Furthermore, there is a micro-cosmos of creativity when the pairing of participants need to think up and express a single idea for a logo; this favors experienced and expert designers as they are *left* to find their own techniques for this.

While the method, and output look similar in the examples, the examples provide us insight into the degree in which the choices of techniques and tools might impact the process. I will not put forward any argument for what example will yield the best result, as it is dependent on more variables than what I've described.

¹ I use brainstorm here as a common term for thinking up a large quantity of ideas without judgment, criticism, restrictions, and quantity over quality and rules to never kill, but mutate and merge ideas. (Osborne 1959; Nielsen 1997; Rickards 2000; Faure 2004; Rawlinson & Graham 2011) But more on that specific and historical technique later.

Methods, techniques & tools defined

Bringing it from the kayaking club, back into this thesis, I propose to stay with the following definitions:

<i>Term</i>	<i>Definition</i>
Method	A collection of subgoals and/or techniques, that when completed, should result in a desired outcome
Technique	A procedure of which to apply a tool in accordance to a goal specified by the method
Tool	The artifact(s) which the technique is applied

While not totally identical, they are similar to the ones proposed by Sanders et al. (2010)

The work on the conceptual background of the muddled terms and definitions in the field of digital design has contributed in more than one way to this thesis. Instinctively, categories and well defined terminology is just good communication and increases understanding (Sauberer 2011). Secondly, during the work, questions such as “is Virtual Reality a tool?” and “A design contest, is that a technique or method - is it not even in this model?” emerge. The immediate answer that comes to mind; is that Virtual Reality is a feature or attribute of the tool, not a tool itself, and that a design contest is a technique, as it will fulfill some subgoal of a broader method. But the work on this leaves more to be desired. Yet for the purpose of this thesis I am satisfied with being able to clearly separate a tool from a technique, and a technique from a method - while understanding that a change in one, will impact the others.

With this work, I have proposed a terminology in which to categorize a creative process, and shown the hierarchical order of the concepts. I argue that this shows the importance of the tool choice in any given circumstance, in the context of the creative process. This further shows that a change in tool, whether it being from one digital platform to another digital platform, or from charcoal to watercolor, has to have a significant impact on the outcome of the creative process.

Solo ideation versus collaborative ideation

As earlier mentioned, there is a vast body of research to suggest that solo ideation yields better results than collaborative ideation. (Osborne 1953; Taylor et al. 1958; Diehl & Stroebe 1987; Mullen et al. 1991; Furnham 2000; Nijstad et al. 2007; Girotra et al. 2009)

The key concepts presented in the following chapter are the fundamental change in structure and thinking needed in a solo versus collaborative setting.

The previous terms of tool, technique and model reveals and defines the tools and techniques to work in unison, impacting each other. Because of this, it makes sense to look into solo ideation versus collaborative ideation, through a certain technique’s perspective.

I've chosen to hone in on arguably the most popular ideation technique in our culture: Brainstorming.

Brainstorming might be believed to be a group activity; maybe with a facilitator to moderate, a whiteboard, post-it notes, blackboard or the like (Nielsen 1997; Rickards 2000; Faure 2004; Rawlinson & Graham 2011) - but that is not necessarily the case. (Daly et al. 2016) The term of brainstorm can be traced back to ad-executive and author Alex Osborn, popularized in his 1953 book *Applied Imagination*. The book takes up a great many ways of ideation and imaginative theory. I however am especially keen on the chapter originally labeled "*Creative collaboration by groups*". Osborne present it as such:

"The early participants dubbed our efforts "Brainstorm Sessions"; and quite aptly so because, in this case, "brainstorm" means using the brain to storm a creative problem—and to do so in commando fashion, with each stormer audaciously attacking the same objective."

- Osborn, 1953, p. 297

Brainstorming is originally the systematic, formalized process of a: *generating* and then b: *selecting* ideas. Osborne calls this thinking creatively, *and* thinking judicially. (Osborne, 1953, p.293) Much akin to the terms of divergence *and* convergence. But in years it has been adapted and devolved by many many practitioners, and as such is more synonymous with *only* thinking up a multitude of ideas/divergent thinking. (Rickards 2000; Faure 2004; Zmigrod et al. 2015) Whilst this does not matter as it is a historical perspective² I would just like to point out that even ubiquitous terms like *Brainstorm* are subject to confusion, misuse and *devolution* over the years - calling for keeping terminology sharp as to what meaning terms convey, as there might be another definition in the not-so-distant future.

The original label clearly specifies *collaboration by groups*. But Osborne is not arguing that the collective is better at *generating* ideas than the individual. Osborne clearly lays out two major pitfalls of brainstorming as both social issues, or as he calls it, *the hazards of teamwork*. The first one is rather obvious: not performing the brainstorming correctly. Failing to adhere to the rules laid out, behaving rudely, interrupting participants and overall bad facilitation of the guidelines and rules of brainstorming. The second pitfall is a more veiled hazard; relying on others to think. Osborn describes this as missing a "mustness" whenever we are in a social setting - I view this as not committing to thinking up solutions because it's a smaller cognitive load to hope someone else thinks of the brilliant idea, instead of doing it ourselves. As the storytelling ad-executive he was, Osborne paints a picture of the "mustness" of solo thinking:

"If we were on a ship and someone asked, "What would you do if we crashed into an iceberg?" most of us would reply: "I have no idea. What would you do?" But if you were alone in your cabin, heard a deafening crash, looked out of the porthole and saw an iceberg, felt the floor sinking beneath you—your intensity of interest would drive you so hard and so fast that it would force you to think up something to

² How the devolution happened and why it is mostly seen as a collaborative process, are not particularly important questions in the context of this thesis - even though interesting!

do. On the other hand, if there were two of us in that cabin, we might just look at each other blankly and wait for the other to suggest something.”

- Osborn, 1953, p. 294

In essence, Osborn’s original version of brainstorm was alternating between being in a group, and being alone, citing the need for mental breaks alone to be useful in collaborative contexts. In another paper, Osborn argues

“One reason for the productivity of group brainstorming is that the power of association is a two-way current. When a panel-member spouts an idea, he automatically spurs his own imagination toward another idea. At the same time, his ideas stimulate the associative power of all the others. “

- Osborn 1958, p. 23

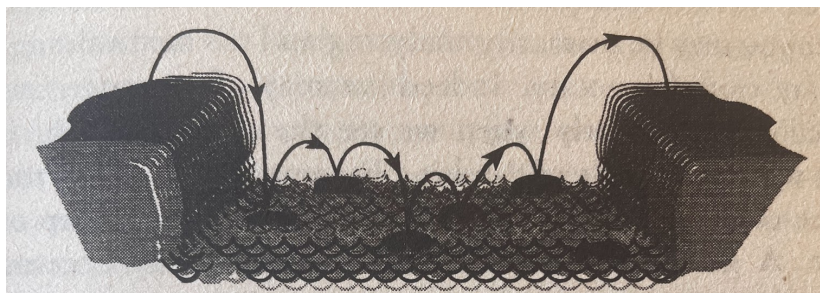
It seems Osborn does acknowledge some benefits of group ideation: *the power of association*. But as mentioned, evidence points to ideation being more effective for the individual, and only after generating ideas, should the participants meet to discuss and select ideas. (Faure 2004; Daly et al. 2016) So while there is power in generating ideas collaboratively - the limits of that collaboration seems not to be a creative thought issue, but a social issue. *This is further backed up by* Couger (1996) that argues the collaboration based ideation is inhibited by social issues and points out three major flaws in generating ideas collaborative:

1. *Fear of social disapproval when expressing true feelings.*
2. *The effect of authority hierarchy - hesitance to expose your ideas in a meeting attended by your boss or even your boss’s boss.*
3. *Domination of the session by a few very vocal persons*

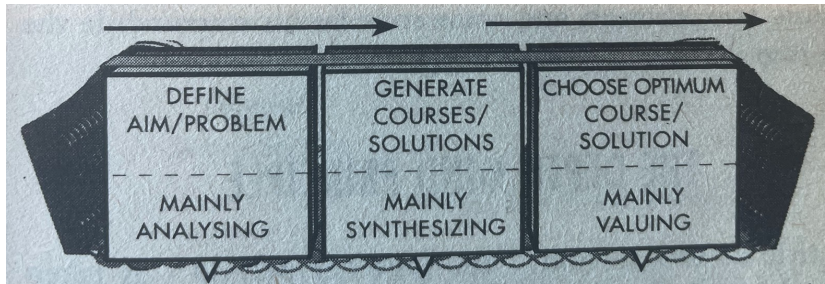
- Couger 1996 p. 157

I argue that these issues, and Osborne’s idea of *mustness* results in why collaboration stifles ideations, overshadowing potential benefits.

Osborne (1958) and Couger (1996) both show social issues hinder the *thinking up* of ideation. But John Adair argues collaborative thinking further changes the *structure* of ideation. His description of individual versus collaborative thinking is shown in fig 03.



“An INDIVIDUAL, when thinking, is like a person crossing a river on stones, jumping to and fro. It’s an untidy but orderly process, using all the meta-functions. [analyzing, synthesizing, valuing]”



“To take a *GROUP* across the river you must build a bridge with three pillars. As you’ll see, these pillars draw mainly on one of the meta-functions, so it helps to be able to separate them.”

Fig 03. Difference when thinking as an individual and as a group. Excerpt from Adair 1996, page 31.

The structural change as shown by Adair (1996) , the *hazards of teamwork* by Osborn (1956) and the social flaws by Couger (1996) all present key differences in solo versus collaborative settings.

Divergent versus convergent thinking

Newells et al. (1962) even argues that Creative Thinking, as a term and theory, is redundant, as there are more specialized ways to describe the way of thinking that produces creative outcomes. In both *Creative Thinking in Business* (Goman 1989), *Creative thinking and Brainstorming* (Rawlinson 1981) & *Relationships between Critical and Creative Thinking* (Baker et al. 2001) the term is used as synonym for divergent thinking, or a slightly modified version of divergent thinking.

To reflect the expansion and contraction of information, in regards to human thought, the terms divergence- and convergence thinking, or at latest terms similar, is used (Clausen & Borch 1996; Goldschmidt 2016).

Divergent- and **convergent thinking** are a subset of productive thought, aimed at certain outcomes. Divergent thinking will seek to increase the possibilities, expanding the pool of knowledge and decisions. Convergent thinking seeks to get to as few answers as possible, gradually decreasing the pools of decisions and information. (Guilford 1957; Goldschmidt 2016)

While Divergence and Convergence describe a thought process, defined by their outcomes, Goldschmidt proposes Mode 1 and Mode 2 as thought processes defined by their cognitive traits. Mode 1 and 2 are *how* one can think divergent or convergent.

Attributes for two modes of thinking	
Mode 1, roughly divergent	Mode 2, roughly convergent
<ul style="list-style-type: none"> • Ideating • Associative • Similarity-based • Intuitive • Fast • Based in memory & emotions • Lateran transformation 	<ul style="list-style-type: none"> • Evaluating • Symbolic • Rule-based • Analytic • Slow • Rational • Calculating consequences • Vertical transformation

Fig 04, Redrawing of Goldschmidt's table of *attributes for two modes of thinking* (Goldschmidt 2016)

Goldschmidt's (2016) work, is a study of ways of thinking, in relation to usages of divergent- and convergent thinking. (Fig 04) In using Mode 1 and Mode 2 instead of divergence and converge, I specify a nuance by using terms that are defined by their inherent attributes, rather than their outcome.

As an example, the difference is shown here:

"Let's all think divergently!" would mean something like:

"Let's all come up with a lot of solutions and ideas!"

"Let's all go into Mode 1!" would mean something like:

"Let's all think fast, in associative patterns and connect with our emotions!"

I argue that Goldschmidt's (2016) work puts a new, practical and implementable, perspective on divergence and convergence with her terms of Mode 1 and Mode 2. Through this thesis, the terms of Mode 1 and Mode 2 to describe 'in *what way to think*', and divergence and convergence are used to describe '*what should the outcome of the thinking be*'.

Revisiting the research question

The following is the research question of this thesis:

How well is solo ideation supported in commercially available digital creativity support tools?

Using my definition of creativity, the term can be separated in three activities of creativity:

- Thinking up ideas
- Expressing ideas
- Judging ideas (*on novelty and/or value in regards to 'the problem'*)

This means that any tool that claims to be a creativity support tool, must then by my definition, support one or more of these activities of creativity. If a tool supports none of these three activities, it is arguably not a creativity support tool.

One thing that strikes me is the inherent goal hierarchy of much creativity; a film in need of a storyboard, a storyboard in need of frames of artwork, frames of artwork in need of sketches and coloring. In that scenario, I do not find it feasible that the creativity activities are completely isolated from one another - yet I argue it is beneficial to think of the three as focal points that one can aim to achieve at a given point in any given creative process.

Further, the research question specifies *ideation*. As I defined and argued, *ideation* is the *formalized process of thinking up ideas*. The model in fig 05 shows what part of creativity I address with this thesis, and research. As such, I point to *any formalized way of thinking up ideas alone* is key to my thesis - ***solo ideation***.

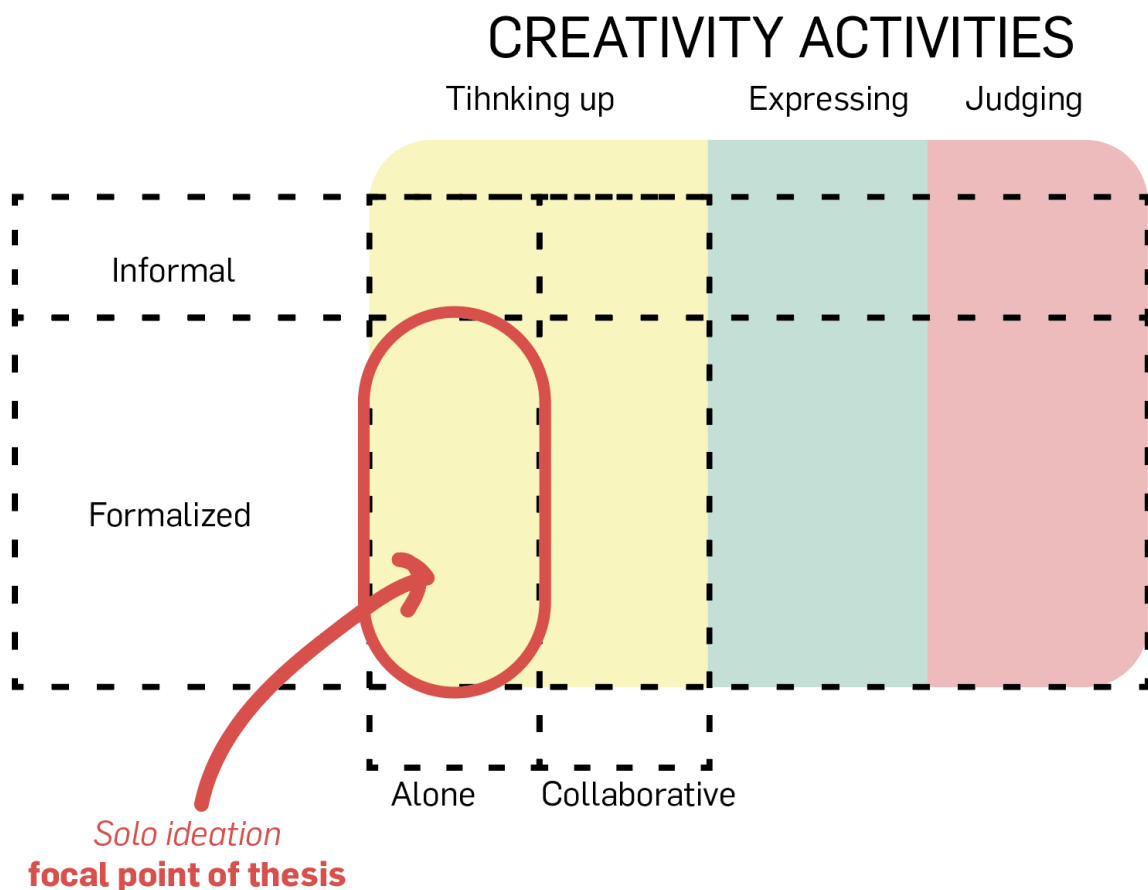


Fig 05, Understanding solo ideation's place in creativity activities.

To summarize, I've included a table of core concepts to consider:

Core concepts to consider

Creativity	<i>A problem solving skill, expressed through a process, where ideas of novelty and value is thought up and expressed</i>
Ideation	<i>Any formalized process to facilitate thinking up ideas.</i>
Method	<i>A collection of subgoals and/or techniques, that when completed, should result in a desired outcome</i>
Technique	<i>A procedure of which to apply a tool in accordance to a goal specified by the method</i>
Tool	<i>The artifact(s) which the technique is applied</i>
Mode 1 of thought	<i>Practical application of ways of thinking, to achieve divergence of thought</i>
Mode 2 of thought	<i>Practical application of ways of thinking, to achieve convergence of thought</i>

Chapter 3:

Analysis to create design aspects

Introduction to design aspects

The following chapters are my work on creating design aspects of the ideal digital CST for solo ideation. The purpose is to *nail down* specific values that any digital CST for solo ideation should hold in high regard. While *not* recommendations for implementation, the aspects should be considered as guidelines for what problems should be addressed in any given digital CST for solo ideation. I uncover the aspects by exploring and analyzing theories and findings within CSTs and solo ideation.

This approach, of creating design aspects, should be seen in a broad perspective. It is a tool-centric approach, **what problems a tool needs to solve**, to be considered an ideal digital CST for solo ideation. But instead of stating them as problems, the design aspects will be stated as *commandments* to promote practical use. This approach is in essence *to find out what the problem(s) a given design should solve, by saying something about what it should be*.

The following seven aspects is identified and discussed:

An ideal digital CST for solo ideation, should...

- 1 ... be digital reliant
- 2 ... stimulate pattern recognition
- 3 ... avoid Mode 2 of thought
- 4 ... be usable by a single user
- 5 ... offer external information
- 6 ... offer relevant information
- 7 ... offer continuous ideation

Aspect #1

... be digital reliant

The scope of my thesis is to improve solo ideation in a *digital* CST. Further, my field of study in a broader sense, is the *Digital Design of Human Computer Interaction*. In this context, it is necessary to delve into the *digital* and *computer* aspect of this subject. The digital sphere is the sphere in which the tool should exist, and as such I have this aspect as the first, since any tool not fulfilling this aspect of digital reliance, does not qualify as a *digital CST for solo ideation*.

But being digital is not just a matter of the field of research being *Human computer interaction*. It is also a matter of ensuring that the ideal digital tool utilizes the benefits the digital sphere can offer solo ideation.

As mentioned in the intro, the digital medium can be of benefit in a CST. Faste et al (2013) presents a global *Tweetstorm*, utilizing the instant global communication of Twitter, exploring Twitter's limitations and strengths, using it to benefit ideation. Chen (2019) could show an AI based image generator sparked an increase in aesthetically pleasing ideation - and Bae et al (2020) concludes that their tool for randomly generating prompts in a Mind Map like system, is more effective than the analog counterpart.

Per my model and definitions, any *tool* must rely on a *technique* to guide the use. An example of an effective, tried and tested *technique* is sketching.(Jonson 2005). It's a technique where the participant draws, visualizing ideas, and by doing so reveals things not apparent in their thought - which then in turn can prompt new ideas and sketches, and so on. (Goldschmidt, 1991) So the technique and the effects of it are clear, but the tools are not specified.

Pen and paper are analog reliant, existing completely separated from a digital sphere. Sketching on a whiteboard with others, still purely analog but a slight different tool than your own pen and paper. Substitute the whiteboard for smartboard and more opportunities for sketching open up³ - it is now also somewhat digital. Are the participants participating from a video call - the digital sphere must certainly have some impact on the process then. A designer might draw on a tablet as well, utilizing a sketching app and stylo - now it's looking even more digital, a hybrid between drawing software that lets the designer do incredible stuff in their sketching, copy pasting small details, creating perfect patterns and colors - utilizing the digital medium in ways no analog tool ever could. But the tool is also the artifact of stylus and tablet, with analog, physical traits, such as resistances, weight and grip that can impact the technique. But it's still a *tool* that can apply the *technique* of sketching. In the far end of the spectrum, and maybe even more speculative, an AI generating art based on user input might be considered sketching as well. So while the technique remains the same; sketching, the tool changes, and the digital reliance shifts as well.

In *The 2019 Annual Design Tool Survey* (Taylor 2019), 86% of the 3149 surveyed designers, utilized analog tools⁴ for ideation. The next-to-most (44%) common way users were comfortable ideating, was directly inside the tools for building UI wireframes. This leaves a gap in the field of dedicated digital CST, as there seems to be no dedicated ideation tool adopted by the community. This is the case even though 45% of research in creativity within digital creativity support tools, focuses on ideation specifically, both introducing new tools and exploring existing ones (Frich et al. 2019, p.7). The discrepancy, in the vast number of tools introduced, research conducted on the subject and then the overwhelming number of designers still utilizing analog ideation leads to the suggestion that ideation has a particular quality, hard to mediate digitally. Or maybe: the pen & paper is ubiquitous, and the use of digital tools is spread thin as to not show in statistics, as the survey speaks to tools, not to medium. Designers might use both, but all pen/peer as analog, but a wide variety of

³ This does not mean it's *better*.

⁴ Pen & paper or whiteboard

digital tools. In fact, digital tools might be more prevalent than pen & paper. The survey conducted the year after (2020) asked about this, and 95% of designers surveyed reported they did use software as tools for brainstorming (Taylor & Jordan 2020). While 2020 might arguably be the year of remote work, the fact remains, digital ideation is spreading and now more relevant than ever.

The examples of the benefits of digital reliant ideation, the booming popularity of digital software for designers and the emerging field of CSTs within Digital Design, makes for a strong case, that a CST for solo ideation that *relies* on the digital medium, will be a significant contribution in a manner of both research and commercial impact.

Aspect #2

... stimulate pattern recognition

De Bono (1995) argues that ideas stem from our brain trying to establish patterns, or sequence information received based on previously received information. He uses an analogy of paths, streams and rivers. He argues that creativity is a combination of a *passive system* of the brain, creating patterns, and then an *active system* in the brain, making sense of the patterns in hindsight.⁵

De Bono further argues that this poses a problem of *the logic of creativity*, as the outcome of creativity will inevitably seem logical, so practitioners try to learn and practice logic, instead of creativity. This hindsight, he argues, is the key for creativity. (De Bono 1995)

As previously mentioned, this pattern recognition is often synonymous with Creativity, such as Bonet & Poulsen (1995):

“Creativity is seeing things, everyone can see, whilst creating new connections and links, which no one has made before”

- Bonet & Poulsen, 1995 p.17 [Translated by author from Danish to English]

While my definition for creativity is not just establishing patterns for the first time⁶ - I will agree that new *ideas* are a rearrangement of the information we already know into new patterns. That is further argued by Leboeuf, in his 1982 book *Imagineering*:

“What is totally new? Can you think of anything that is? I can’t. Every idea or thing is an extension, synthesis or duplication of previous ideas and/or things. New books are a rearrangement of old words, ideas and concepts. New paintings are rearrangements of color, canvas and skill. New scientific breakthroughs are built on existing fundamental principles [...] Most of our ideas result from associating the ideas of others.”

- Micheal Leboeuf 1982, p.14

⁵ Not to be confused with left brain / right brain theory (Leboeuf 1982; de Bono 1995)

⁶ My working definition is, as laid out in the 'Creativity' chapter: *“A problem solving skill, expressed through a process, where ideas of novelty and value are thought up and expressed”* .

“Understanding that the cornerstone of new ideas lies in the association of old ones gives all of us the ability to create idea almost at will”

- Micheal Leboeuf 1982, p. 56

This premise of *thinking up* ideas, could then be defined as *associative thoughts, conscious or unconscious, in patterns of recognition that will appear logical in hindsight - resulting in a novel idea.*

I believe it to be shown that associative thought, pattern recognition, is then the base of any ideas. This is also what was noted in a workshop by Christain Kohls (2015). Not only did the results seem to further confirm the theories of pattern recognition - but Kohls and the workshop participants identified and defined three ways that the patterns present themselves:

-
1. **Multiple Perspectives** is about seeing a situation more holistic
 2. **Idea Trigger** is about stimulating thought into useful directions
 3. **Random Impulse** is about giving your thoughts a new and unexpected direction

Three patterns that can generate ideas, as explained by Kohls (2015)

While this chapter should be a recommendation of specific implementations, I argue that these three are categories of *pattern recognition stimuli*. So in any CST, that aims to fulfill this aspect of pattern recognition, should contain features to promote at least one of the three.

Aspect #3

... avoid Mode 2 of thinking

“The discrepancy between the creative impulse and the input needed to activate digital commands often leaves the designer bound to a process that steers him away from design thinking.”

- Dorta 2007

Dorta points out that there is a paradoxical aspect to digital CSTs in regards to what he calls *design thinking*. In his context, design thinking is not further described, but seems to cover problem-solving ideation. (Dorta 2007) The paradoxical aspect, Dorta points out, is that ideation seemingly requires defocus, but a digital tool seems to require focus. Defocus is a key attribute of Mode 1, while and focus is key in Mode 2. Goldschmidt's (2016)

That the digital medium historically is seen as antithesis to creativity, is backed up by an earlier experiment by Bilda & Demirkan (2003)

“[...] digital media seems to be inconvenient for the conceptual design phase [in this thesis: ideation], this situation depends on designers' designing habits and the inflexibility of the CAD software.”

- Bilda & Demirkan 2003, page 49

I will however argue that digital tools have come a long way since Bilda & Demirkans work in 2003, and Dorta's work in 2007. I have found no comprehensive studies on the ideation software of the late 00's. But for reference: in 2007 only 54% of European households had internet access, and only 8% of EU citizens reported having good e-skills.⁷ The number of households in the EU with the internet has grown to 98% in 2021, and the EU commission no longer measures 'e-skills'. While the following is conjecturing, as I have not reviewed nor tried 2007 software, since 2007, I would assume that the software of 2007 would most likely be considered outdated in regards to today's UX standards.

But that is not to say the observations and experiments conducted in those years aren't relevant, or important. They prove a point in that any digital CST must strive to enable Mode 1 of thinking, and not Mode 2. And while software development most likely have been more concerned with UX in later years, I would argue that the increasing possibilities of computing and the digital medium, increases the *need* for proper UX design.

The antithesis of Mode 1, is Mode 2. Mode 2 is where the user concentrates on solving problems, allocating brain power for evaluation and analysis among other traits (Goldschmidt 2016). Any tool that lowers resistance for the brain to work in Mode 1, must then purposely avoid attributes that require Mode 2 to engage in. Any technique and tool to facilitate ideation should then, generally, facilitate divergent thinking, by avoiding Mode 2, to better work in Mode 1. I propose then this aspect, that the ideal digital CST for solo ideation, should avoid Mode 2 of thinking.

Concept Maps & Mode 2

Accepting this, that creative thought can be represented by an associative pattern of recognition - we can start to visualize creative thought. An attempt to represent information on a subject, which represents the thinking itself in a concept map (Novak 2010) as seen on fig 06.

⁷ That this was a point where we could just bundle everything a user would do on a computer into *e-skill*, should be a telling sign of the lack of depth, variety and development in the commercially available software at the time.

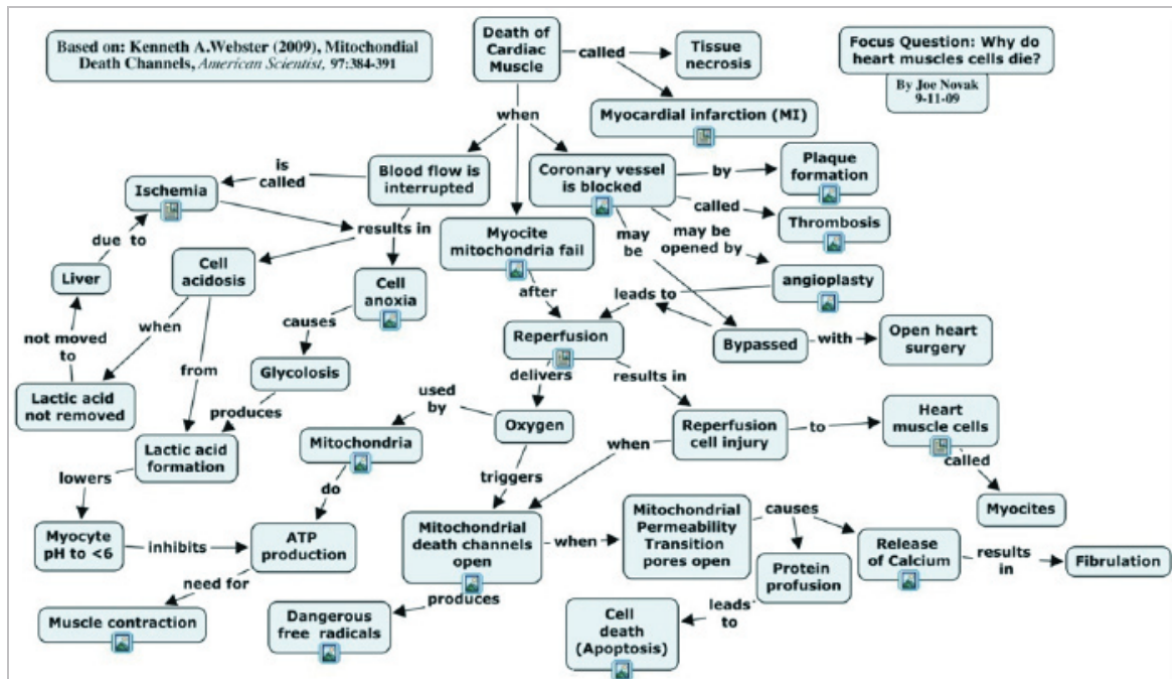


Fig 06, concept map (Novak 2012)

The concept map is meant to be read, and analyzed - a great way to create an overview of a given subject as it offers rules on questions, arrows, dependencies. They are meant to represent knowledge. (Lucidchart.com; Novak 2010) This is not ideal for divergent thinking or Mode 1, as it requires an analytical approach more akin to Mode 2 (Goldschmidt 2016) - analyzing, categorizing, being selective and critical of concepts and relations. Creating a concept map is the Mode 2 way of creating a representation of the associative thoughts, in a holistic view. This *can* lead to pattern recognition to spark new ideas, as it is Multiple Perspectives (Kohls) pattern recognition. This does not change the fact however, that the ease in which the concept map is read and understood, will impact ideation through modes of thinking (Buzan 1993; Goldschmidt 2016)

Mind Maps & Mode 1

Mind mapping is the technique of visualizing a title⁸ in the middle of a canvas, and then branching out into associative notions (Buzan 1993; Bonet & Poulsen 1995). The term Mind Map was proposed as a new note-taking technique by Tony Buzan back in 1970, trademarking the term in 1989 (Wipo Global Brand Database). Fig 07 shows a model of a Mind Map, in its simplest form.

⁸ Title in this context does not necessarily mean 'a word'; usually it is either a word, an image/illustration, or a combination of the two (Bonet & Poulsen, 1995)

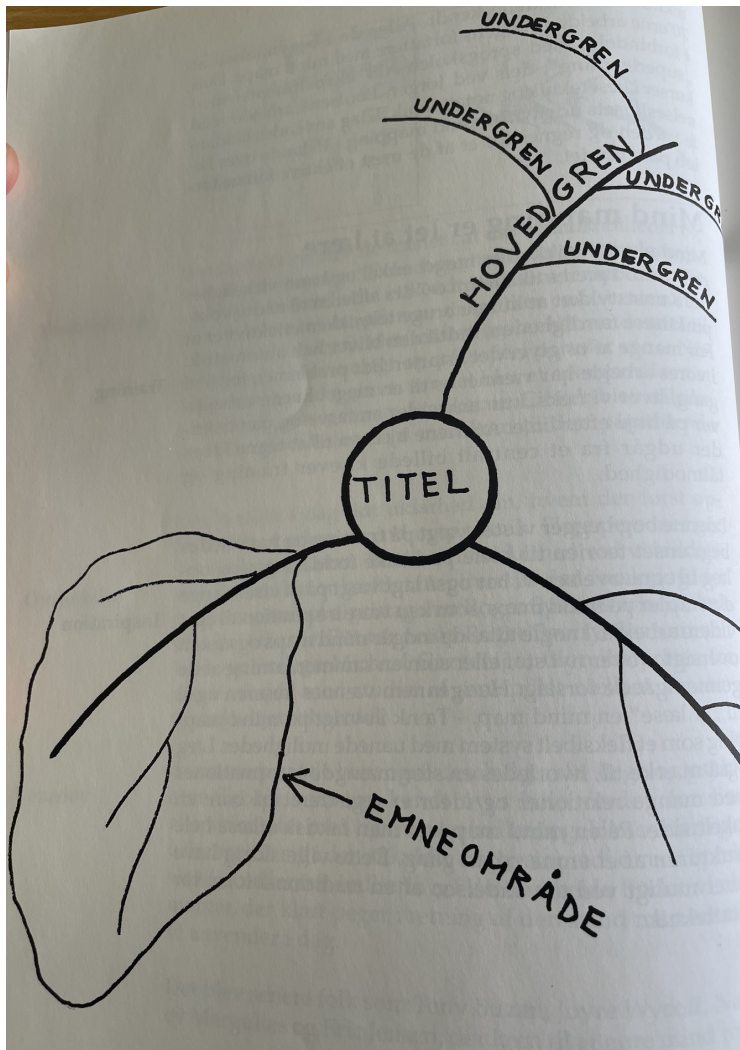


Fig 07. *Mind Map example*,
from *Kreativ Mind Mapping*
Bonet & Poulsen 1995

Branching out from the center, the *main branches* sprout, these are tilted with broad subjects first associated with the central titles. These branches are named key branches. Key branches then have subbranches, with notions associated with the branch on which they are grafted - and so on (Bonet & Poulsen 1995). Buzan (1993) originally intended the technique for taking notes - where the aim was to free up cognitive power in the brain as fast as possible during the learning process, so as to be a better and faster learner - remembering better⁹. It is clear that this is the purpose for Buzan back in 1993 in his book *The Mind Map Book*. (Buzan 1993)

Nowadays however, we can see Mind Maps used in creative thinking contexts as well (Michalko 2001; Chen 2008; Bae et al. 2020). Michael Michalko, in his book *Cracking Creativity: The Secret of Creative Genius* describes mind mapping as follows:

“A mind map is a tool to help us deliberately and consciously extend our associations so we can make imaginative connections and unleash our creative powers”

- Michalko 2001, p.62

⁹ Buzan's earlier research was most in the field of memory such as *Use your head* 1974, *Speed Memory* 1977 and *Use Your Perfect Memory* 1991

A common use, and in some contexts; misconception, of the Mind Map is that each node of the map should contain an idea, as seen in fig 08.

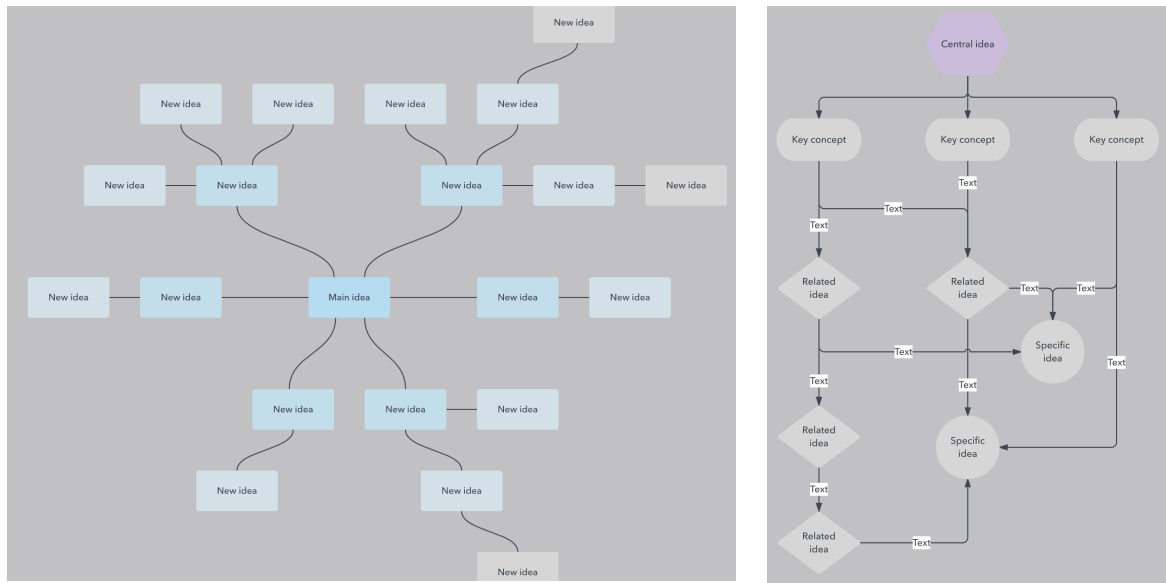


Fig 08, Lucidcharts example of a Mind Map (*left*) and Concept Map (*right*) (*lucidchart.com, last retrieved 2022*)

While it is possible to have ideas in a node, this does not seem to be the intention, nor the optimal way to Mind Map. The nodes/notions in the Mind Map should not be ideas in itself, but a visual representation of the user's thoughts (Buzan 1993; Bonet & Poulsen 1995; Michalko 2001; Chen 2008;).

While I have not been able to pin-point the specific point in time where Mind Maps was first adopted in design and ideation, it was early on used to visualize problem solving questions (Bonet & Poulsen, 1995). Chen (2008) argues that Mind Map can substitute traditional thinking in problem solving with divergent thinking and I concur. By removing the texts, questions and answers and replacing them with a pattern of associative notions related to the product, the conditions for divergent thinking is better - or conditions for convergent thinking is worsened at least. Buzan argues that the reason why Mind Mapping is great for taking notes, is that the user can manage their thoughts in a manner which is pleasing and natural to the brain, thus reducing the strain on the brain. Buzan originally intended to allocate this newly freed up brain power to better listen, learn and remember. I think the reason Mind Mapping is adopted into the plethora of techniques for ideation, is that this freed up brain power, if directed appropriately, will start to diverge the thinking. I would argue, Buzan created a powerful technique to facilitate Mode 1 of creative thought; it will allow the user to defocus while still having an anchor in relevant and associative patterns related to the subject available to elaborate on. By this way of looking at it, the notions/nodes on the Mind Map, are not the ideas, but a pattern that acts as a source of inspiration in which to relate, explore and think up ideas.

Mind Mapping helps the user sort information and associations efficiently, which results in an increase of mental capacity. Buzan (1993) argues that Mind Maps require more

than lines and titles. To be an efficient technique, Buzan lays out four laws for a successful Mind Map technique.¹⁰

1. **Use emphasis**
2. **Use association**
3. **Be Clear**
4. **Develop a personal style**

- Buzan 1993, p. 94

These laws are to ensure that the user does not restrict their own ability to create order (*the mind map*) from chaos (*their associative thoughts*). Relating this to pattern recognition, I view de Bono's (1995) lateral thinking, and logical hindsight to be mirrored in the chaotic thought of association and order of mindmapping.

More on Mind Maps & exemplified Mode 1

The laws of Mind Maps are argued to be key for the technique to have a great effect on creativity. (Buzan 1993; Bonet & Poulsen 1995; Michalko 2001) The following is an explanation and discussion of each, to exemplify the facilitation of Mode 1 of thinking. I show that the laws laid out have a general way of utilizing concepts to free up memory, applicable in most ideation and thus further the argument for facilitation of Mode 1 in a digital CST.

1. Use emphasis:

To use emphasis in this context, is to make your Mind Map pop. A center notion is crucial, but so are images, line thickness, styling, spacing and colors. Images or stylized words are preferred over bland text. (Fig 09)



Fig 09. Examples of stylizing words in accordance to emphasis in a mind map context. (Buzan 1993, p. 98-100)

The goal of emphasis is to break the monotony, to give life to the Mind Map while emphasizing what the impactful associations of the notion are. (Buzan, 1993) So to

¹⁰ In the original list, Buzan has two *laws of layout* as well: hierarchy & numerical order - Hierarchy is the principle for centric "broad" notion, branching outwards, and numerical ordering is only relevant for note-taking. (Buzan 1993) As I've already covered the importance of a centric notion, and note-taking is not of great interest to this thesis, I've discarded the two from this elaboration on the laws.

emphasize meaningfully, one must let the part of the meaning of the words be conveyed through style and imagery, not just the word itself.

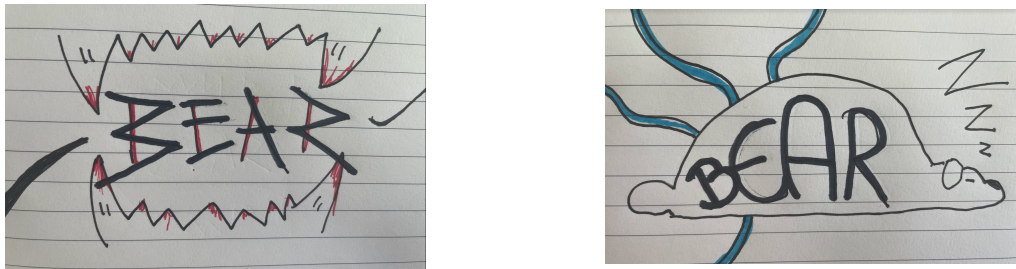


Fig 10. Example of stylizing a word. The word bear, but highly stylized in two different ways, conveying two different meanings and associative patterns. (self)

While not described by Buzan himself, I find this to be a way to force the brain to work out what the meaning of what the specific association is, and how it connects to the previous. In other words, I find the law of emphasis to ensure the user personally engages with the Mind Map in a way that stimulates associations.

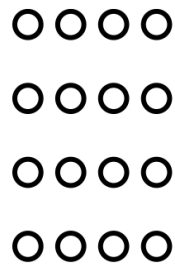
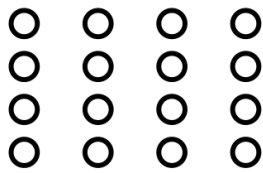
2. Use associations:

While the word *association* is written many times in this thesis, the goal with association in this manner is to clarify and reveal the associative patterns of the Mind Map. To associate is to give spatial directions to your thoughts. (Buzan, 1993 p. 100). The associative layout is noted to be of great importance by Michalko (2001):

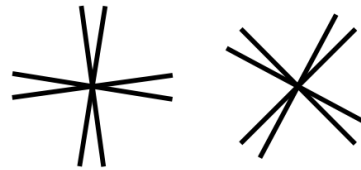
“Mind mapping allows you to group and regroup concepts, encouraging comparisons. Moving and synthesizing concepts into new clusters often provokes new ideas”
- Michalko 2001, p.66

Colors, codes, arrows and links all contribute to make the Mind Map easy to decode and elaborate on. I cannot help, but draw the connection to the more elaborate Gestalt Laws, used commonly in UI design. (Lauesen 2005) The gestalt laws describe in what manners one can organize visual elements in such a way they convey a coherence and associations. (Brunswick & Kamiya 1953; Elder & Goldberg 2002; Lauesen 2005)

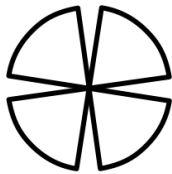
**Example A:
Law of proximity**



**Example B: Mill wheels
Law of proximity**



**Example C:
Law of closure**



**Example D:
Law of good continuation**

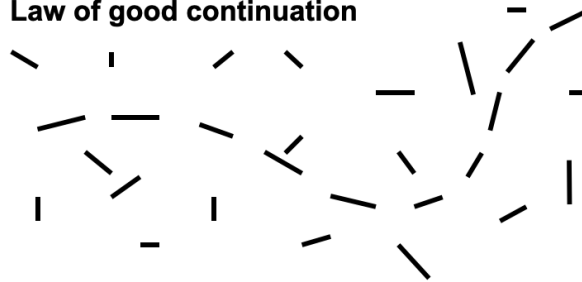


Fig 11. Examples of gestalt laws (Lauesen 2006, slide 3)

Association in creating a Mind Map, should be used for order and to limit the brain power needed for the user to *decode* their Mind Map. (Buzan 1993; Ayoa 2015)

3. Be Clear:

Clear Mind Mapping follows certain principles:

- one key word per line
- make words easy to read (not sloppy handwriting, think printed letters),
- no crossing lines,
- recognizable imagery.

These are all to minimize the brainpower required to decode Mind Map at a glance. (Buzan, 1993) While this might be an argument for a minimalistic Mind Map, when combined with *emphasis* and *association*, the Mind Map will most likely result in an organic and colorful picture, rather than a minimalistic one. I summarize that a good Mind Map is a balance of the two: letting the associations flow in an unfocused state, akin to sketching (Jonson 2003), stimulated by colors, imagery, shapes and the like all while keeping the aesthetic somewhat clear and orderly to quickly associate and understand further.

4. Develop a personal style:

The law of personal style, is to ensure the personal connection with the Mind Map. An effective Mind Map reflects its creator's brain patterns, and forces it to associate. For this reason the Mind Map should be created in a way that is appealing to the individual creator's preferred way of *decoding* and *reading* the Mind Map. (Buzan 1993; Bonet & Poulsen 1995)

The best Mind Maps are personal ones.

Summary of Mode 1 & Mode 2

As presented, Mode 1 of thinking is desired for ideation. As discussed, and exemplified with the laws of Mind Mapping - Mode 1 this is not *only* about promoting certain ways of thinking, but just as much, if not more, to avoid Mode 2 of thinking. It is crucial for any digital CST for solo ideation, that the tool should avoid forcing Mode 2 of thinking onto the user in a given ideation process.

Aspect #4

... be usable by a solo user

The ideal digital CST for solo ideation, should *obviously* be usable by a solo user. John Adair's visualization for individual thinking (Adair 1996) depicts a pattern of the skips and hops in an untidy, yet orderly process, is not dissimilar to De Bonos analogy of streams and rivers. I view Adair's paradoxical nature of individual thinking, *untidy yet orderly* to have the same reasoning behind it as De Bono's logic of creativity. It is only after the fact, that we can view the individual's thinking as orderly. This similarity between *thinking up ideas* and *individual thinking*, strengthens the argument that thinking up ideas is best left to the individual. To prove the point further, I point to the structure for collaborative thinking (Adair 1996) to be a structured process from the get-go, directly countering the premise of creative associations laid out by De Bono.

To back this up further; in the scope of brainstorming, numerous studies have been to investigate solo versus collaborative brainstorming. (Diehl et al 1987; Paulus et al 1997; Nijstad et al 2006)

Diehl & Stroebe (1987) collects more than 22 experiments of collaborative brainstorming, in 18 of them the individual ideaters performs better than the groups.¹¹ In four of them, notably the ones where the collaboration was in pairs of two, instead of groups, there was no significant difference between individuals and collaborative brainstorming. This leaves zero. Out of the 22 studies identified as experimenting with individual ideation versus collaborative ideation, zero studies could show the group to perform better in ideation. (Diehl & Stroebe 1987) Hence it is paramount that the ideal digital CST for solo ideation, is designed and tailored to suit the needs of an individual, rather than the ones of a group.

As a guideline, this means the tools should facilitate fast-paced and somewhat chaotic ideation - with the key ability to recognize patterns in a *logic of hindsight*. With Adair's differentiation of the solo versus collaborative thinking - Solo ideation is thus an aspect that will have effect on what kind of structural impacts a given tool will have on the ideation process.

¹¹ The definition of performance differentiates slightly, weighing quality, quantity, or novelty somewhat differently.

Aspect #5

... offer external information

De Bono (1995) suggests a completely random word, as a prompt, would benefit the ideation process more than nothing - arguing the human brain will always try to establish patterns, and in that pattern an idea will be born.

“The random word provides a new entry point and as we work back from the new entry point, we increase the chances of using patterns we would never have used if we had worked outwards from the subject area” (De Bono 1995, p. 18).

In this quote, De Bono argues that given additional entry points in ideation, the pattern recognition that leads to ideas, is stimulated in ways that are better than no stimulus. This theory is tested in a study in 2014, by Belski et al. They test groups of engineering students to solve a given problem. The problem given was regarding copper pipes clogging up, and the goal was to come up with as many good™ ideas as possible within a limited time frame. One group of students were given no further prompts, while another group were given seemingly random words as prompts for ideation: *Archaism, Right angle, Lotus eater, Emitter, Ozone, Blowhole, Ball-and-socket-joint and Hanky-panky*. The study confirms that the students with random words are more successful in generating ideas than the group without any word prompt, confirming De Bono's theory.

Aspect #6

... offer relevant information

To push the boundaries and test the theory further, a third set of students was given multiple words vaguely related to the problem: *Heating, Cooling, Isolation, Optics, Plants & Vibrations*. The students with vague words did even better than the completely random ones. (Belski et al. 2014) Accepting this premise, I argue that prompts of information to stimulate and invoke a *pattern* of recognition and relation, even vaguely *associated* to the problem/starting point, must then be beneficial to ideation. This is further backed up by Chen et al. (2018) that found ideation based on sources closely related to the subject matter was more efficient than ideation based on sources far away from the subject matter. Chen (2018) created a semantic ideation network, based on associative terminology, to test this out. They conclude:

“According to results of our case study, the semantic ideation network is able to provide a variety of cross-domain associations and progress the ideation process forward quickly and easily ...”

- Chen 2018

In regards to external relevant content, there is discussion on this to be had. External content, in a creative process, might cause *design fixation*; from here on: *fixation*. (Jansson & Smith 1991; Youmans et al 2014; Crilly and Cardoso 2017). Fixation in this sense, is a term to describe how a designer limits themselves in *“a blind adherence to a set of ideas or concepts limiting the output of conceptual design”* (Jansson & Smith 1991: p. 3). Whenever

fixation occurs, the designer limits themselves, resulting in a worse creative process than would otherwise occur. Fixation has been specifically studied in the context of design and creativity since the 90's (Crilly & Cardoso 2017) - yet I have not been able to find an answer to where to draw the line: *what external content is causing fixation and thus problematic, and what external content is causing pattern recognition in a beneficial way?* In other words, more specific for this design aspect and context: *what external content is relevant?* Sio et al (2017) presents this question as *Fixation or Inspiration?* in a meta-study of experiments regarding fixation in the design process.

“...the quality of solutions ideas was positively correlated with the degree of copying from examples. The facilitatory effects on novelty and quality increased when fewer and less common examples were presented.”

- Sio et al 2017

However, what I find in this study, and what the study fails to mention, is that fixation is only researched with experiments in which the practitioner is presented with existing solutions to their problem.

I would assume, some form of fixation could occur without being presented with existing solutions - but maybe specific notions or the like. This assumption builds on what Belski et al 2014 could show. Better results when designers were given prompts associated with the field of the problem, than with completely random ones. So one could assume that prompts relating to each other, but not to the field of the problem, would narrow the ideation away from the field of the problem. This is of course purely speculation, but nevertheless shows the ambiguity of external content in ideation. The research on fixation leaves this notion of *relevance* in a state where it must depend on context and objective for each CST.

So while I surmise that it's not plausible to say *what* specific content is relevant to present, in a universal sense of digital CST for solo ideation, I believe I can argue on the way in which the information is presented.

Aspect #7

... support continuous ideation

To reiterate, the *blindness* caused by fixation is a clear concept, and a pitfall of ideation, with a negative outcome.

“Student designers, working individually, had to generate ideas in response to different problems (i.e. design a car-mounted bicycle rack, a measuring cup for the blind, a disposable spill-proof coffee cup). Alongside the design briefs, some of the participants, were also presented with pictures of existing solutions. Jansson and Smith identified the occurrence of fixation in their experiments when it was observed that the designers exposed to those pictures tended to repeat key features of the solutions that were represented. This behavior persisted even when participants received instructions to avoid repeating particular features of those example solutions. As these features were intentionally problematic (e.g. they contradicted the brief) this feature repetition was taken to be inadvertent and counterproductive.”

- Crilly and Cardoso 2017, about the experiment of Jansson & Smith

The study clearly shows a negative impact upon the designer receiving some external information (*in this experiment, it's other ideas for solutions to the problem they try to solve*). This is of course not ideal for the ideation process, and as such, must be targeted for elimination in a digital CST for solo ideation. In the previous chapter, I concluded that relevancy of information is not ubiquitous and hence, it is up to each CST, or practitioner to define relevance within their context. I will however elaborate on the way external information is presented.

Youmans et al (2014), Identifies three different ways fixation occurs: *Unconscious adherence*, *Conscious blocking* and *Intentional resistance*. Common for the three, is that the practitioner's locking on to particular patterns, not breaking them or moving beyond certain ideas or notions. The remedies for each include some version of inspiration from external sources. (Youmans et al 2014) With this I argue that the key to countering fixation is *continuous ideation facilitated by relevant external information*. Continuous in this sense means it can be built upon, seemingly endlessly. While common sense might tell us that any ideation is continuous in the way that the brain can keep on thinking and thinking - this aspect is to clear up what the tool should offer the user, and not what solo ideation should be in isolation. As such; I view the continuous ideation to be a responsibility of the CST, to ensure the ideas generated can be continuously expanded upon, with external input. If the external information presented, is of limited quantity, and *runs out* before the users needs for external information input are met, the tool will fail to counteract fixation. The user will in that case run the risk of being stuck in fixation, and must rely on their own expertise and experience of ideation to combat it. On the other hand, if the tool possesses the ability to present relevant external information to the user at all times, I argue that this risk is greatly reduced and the burden of avoiding fixation is moved from the user to the tool itself.

The aspect of *continuous ideation* is as such incorporated to ensure that the agency of avoiding fixation, by continuously stimulating pattern recognition, lies with the tool, and not the user.

Summary of design aspects

The following is a summary of the knowledge uncovered, combined and discussed, in seven design aspects for the ideal digital CST for solo ideation. I've formulated the aspects in Imperative sentences, as to mimic seven actionable commandments to follow, were one to further research, experiment and develop a digital CST for solo ideation.

An ideal digital CST for solo ideation, should...

1 ... *be digital reliant*

2 ... *stimulate pattern recognition*

3 ... *avoid Mode 2 of thought*

4 ... *be usable by a single user*

5 ... *offer external information*

6 ... *offer relevant information*

7 ... *offer continuous ideation*

I've included *action cards* with core arguments and key text for each aspect, in appendix A, to ease the future use of this work.

Chapter 4:

Review of the field of commercial tools based in design aspects

This chapter presents my review of existing digital CSTs for ideation. I've conducted a review of existing commercially available tools, by evaluating them in accordance with my design aspects, to investigate how well solo ideation is facilitated in commercially available tools.

Selection of tools for review

The goal of my review is to get an overview of the existing tools available to digitally ideate, and what the benefits and limitations of those tools are in the context of solo ideation. The tools are picked from searching in three search engines based on relevant search terms, combined in pairs or as three in different combinations, order and conjugations, and the following criteria:

Criteria	Search engines	Search terms
The tool is targeted towards ideation; The tool is available to review; The tool is digital & web-based ¹²	<i>Google.com;</i> <i>Scholar.google.com;</i> <i>dl.ACM.org</i>	<i>Ideation; digital; tool;</i> <i>brainstorm; mind map;</i> <i>mindmapping; inspiration;</i> <i>generator; ideas; creative;</i> <i>web based; browser;</i> <i>divergent thinking; problem</i> <i>solving; concept map;</i> <i>association;</i>

This resulted in a list of 23 commercially available digital ideation tools to review:

Name	LINK (Last retrieved August 2022)
Mindmeister	https://www.mindmeister.com/
Lucidspark	https://lucidspark.com/
Mural	https://mural.co/
FigJam	https://www.figma.com/
Adobe XD	https://www.adobe.com/dk/products/xd.html
Whimsical	https://whimsical.com/
Canva	https://www.canva.com/en_gb/
Miro	https://miro.com/
MindView	https://www.matchware.com/mind-mapping-software
XMind	https://www.xmind.net/

¹² Being web-based, using *digital* might seem redundant - however, my aim with *digital* was to exclude analog tools mediated through the web, i.e webcam based ideation or smartboard in a classroom available in browsers to students.

KeySearch	https://www.keysearch.co/tools/brainstorm-niche-ideas
Word Association Network	https://wordassociations.net/en
Idea Generator	https://www.portent.com/tools/title-maker/?idea=Kayak
Generateideas.AI	https://www.generateideas.ai/
Visuwords	https://visuwords.com/
Picular	https://picular.co/
Random word generator	https://randomwordgenerator.com/
Namerobot's Brainstorming tool	https://tools.namerobot.com/brainstorm
IdeaFlip	https://ideafliip.com/
Stormboard	https://stormboard.com/home
Bubblus	https://bubbl.us/
Mind24	https://mind42.com/
HelloScribe.ai	https://app.helloscribe.ai/writing/brainstorm

The 23 chosen tools were put in a table, alongside the following 16 attributes:

- Available in web browser
- Dedicated Mind Mapping
- Capable of Mind Mapping
- Can facilitate Ideations
- User input
- External information (EI)
- Randomized EI
- Related EI
- Procedural EI
- Multi-purpose tool
- Single-purpose tool
- Clear UI
- Cluttered UI
- Can visualize relation of thought
- Offers collaboration
- Ideation Management

The attributes were selected on a basis of what I deemed relevant based on what I saw differentiated the tools. I would then see what attributes were fulfilled by the field of tools as a whole - as shown in fig 12.

ATTRIBUTES	TOTAL Y	
		24
Available in web browser	92%	22
Deidcated Mind Mapping	29%	7
Capable of Mind Mapping	63%	15
Can facilitate Ideaitons	100%	24
User input	100%	24
External information (EI)	38%	9
Randomized EI	13%	3
Related EI	25%	6
Procedural EI	21%	5
Multi-purpose tool	50%	12
Single-purpose tool	50%	12
Clear UI	83%	20
Cluttered UI	17%	4
Can vizualize relation of thought	71%	17
Offers collaboration	63%	15
Ideaition Management	67%	16

Fig 12 *Tool attributes and their overall score within the field of digital ideation tools.* (Appendix B)

I realized this to be insufficient. The attributes, while relevant to the field, were not grounded in any specific concepts or theory in the field. This meant they failed to convey any meaningful score for each tool, as the attributes did not hold any specific value of success or effectiveness. In essence, this was not enough for a review, but seemed sufficient for validating the selection. So while this initial review scored some sort of relevancy for each tool - I realized the need to sharpen the review. While this thesis should not be a day-to-day journal of my work, I've kept the initial review attributes as it offers insight on what tools were chosen, and why. Showing the initial attributes as insufficient, strengthens the argument for why design aspects are valuable - as they can convey effectiveness and success better than quasi-relevant attributes

Exclusion of tools developed for research purposes

This selection further meant tools developed and implemented for research purposes were excluded. In my search, there were three prominent digital ideation tools developed in academia. These are shown in fig 13.

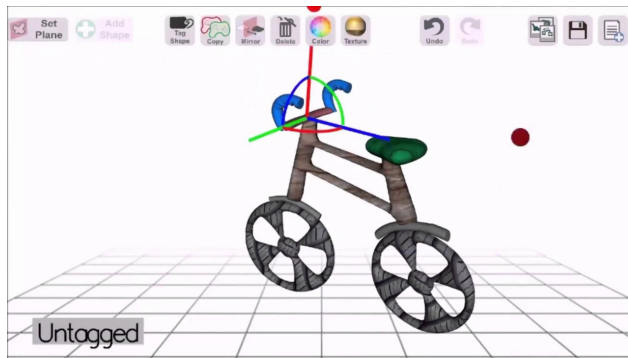


Fig 13a
Co-3Deator (Piya et al. 2017, ACM SIGCHI, 2017
(https://www.youtube.com/watch?v=DH1Wvk_Q6k8)



Fig 13b
ImageSense, picture from Koch et al. 2020
<https://dl.acm.org/doi/pdf/10.1145/3392850>

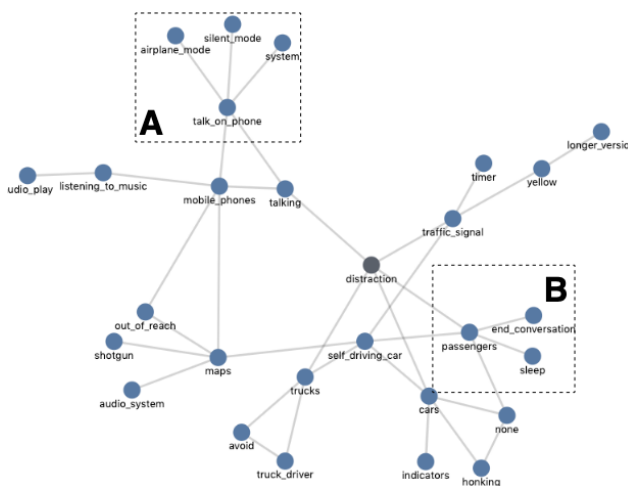


Fig 13c
Spinneret¹³, Bae et al 2022.

As seen in fig 13, tools developed in the field of research commonly lack finish - often still in a form of prototyping phase as described by their respective designers (Piya et al 2017; Koch et al. 2020; Bae et al. 2022). Further, none of the tools are accessible to me, for reviewing. Not to say their contributions aren't of use, or that I have disregarded them - in this thesis the work surrounding the three tools are used as conceptual background and arguments in earlier chapters. They are further examples of how digital CSTs research is mostly concerned with investigating human behavior through a tool, rather than the tool itself. As my work is on the full spectrum of design aspects of a digital CST, it is preferable for my reviews to only contain finished tools that claim to offer the full experience of a digital CST.

¹³ What interface is available to view from their paper at least, the full interface and interaction is not found.

The review sharpens

To conduct the review, I used the design aspects, grounded in research, analysis and discussion. I made the aspects useful for review by turning them to questions:

1. *Is the tool digital reliant?*
2. *Does the tool stimulate pattern recognition?*
3. *Does the tool avoid Mode 2 of thinking?*
4. *Is the tool usable by a single user?*
5. *Does the tool offer external information?*
6. *Does the tool offer relevant information?*
7. *Does the tool offer continuous ideation?*

This way, the questions will indicate how well a given tool solves the problem each aspect reflects. I evaluated the tools in regard to my design aspects, on a scale that goes from yes to no, on a spectrum of 0 to 5, as seen on fig 14.

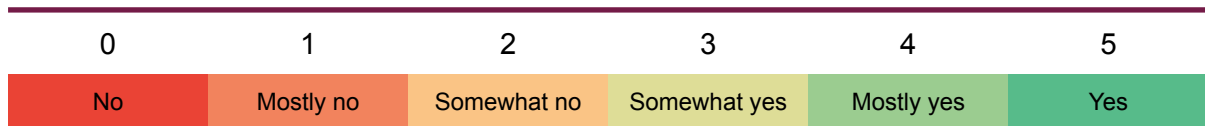


Fig 14. Possible scores in the review

I left no middle ground as to apply pressure of making arguments for deciding on which side of yes/no each aspect falls. The nature of the review is qualitative, even though it is somewhat presented as a qualitative review. The qualitative nature of the review, makes it subject to, and is biased by, my opinions. Because of this, I have made arguments for my opinions, that is the baseline for the scores given. As it would be a cumbersome and resource-heavy task to write out in-depth arguments for all 26 tools in all seven aspects¹⁴, I have shown my capabilities, and reasoning for three vastly different tools in a later chapter.

The aggregated score of a tool, is then the overall efficiency of which the tool can be theoretical ideal for single user ideation in a digital medium. This resulted in the following score table, fig 15, found in appendix B.

	Mindmeister	Lucidspark	Mural	FigJam	Adobe XD	Whimsical	Canvas	Miro	MindView	XMind	KeySearch	Word Associati Idea Generator	Generatidea	Visuwords	Picular	Random word (Namerobot's Br IdeaTip	Storboard	Sublin	Mind24	Heit				
Is the tool digital reliant?	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	4	4	4	4
Does the tool stimulate pattern recognition?	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	3	3	3	3
Does the tool avoid Mode 2 of thinking?	2	2	2	2	1	2	2	2	2	1	2	0	0	0	0	0	0	0	0	0	2	1	1	1
Is the tool usable by a single user?	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Does the tool offer external information?	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	0	1	1	1
Does the tool offer relevant information?	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	0	0	0	0
Does the tool offer continuous ideation?	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	3	3	3	3
Score	15	15	15	15	14	15	15	15	15	14	15	20	20	21	26	22	23	23	15	20	14	14	14	14
Success%	43%	43%	43%	43%	40%	43%	43%	43%	43%	40%	43%	97%	97%	80%	76%	83%	86%	43%	57%	40%	40%	40%	40%	40%

Fig 15. Overview of the scoretable¹⁵ (Appendix B)

¹⁴ With a four page average per review, writing each one out in detail would result in 92 pages of detailed reviews. I believe that degree of thoroughness to be redundant for the scope of this thesis.

¹⁵ The aspects are slightly differently phrased here, as it reflects an earlier snapshot of my process

Analysis of the review

Some tools seems to have an almost identical score pattern:

	Mindmeister	Lucidspark	Mural	FigJam	Adobe XD	Whimsical	Canva	Miro	MindView	XMind	IdeaFlip	Stormboard	Bubblus	Mi
Is the tool overtly digital?	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Does the tool stimulate pattern recognition?	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Does the tool offer continuous ideation?	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Is the tool usable by a single user?	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Does the tool avoid Mode 2 of thinking?	2	2	2	2	1	2	2	2	1	2	2	1	1	1
Does the tool offer external information?	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Does the tool offer relevant information?	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Score	18	18	18	18	17	18	18	18	17	18	17	17	17	17
Success%	51%	51%	51%	51%	49%	51%	51%	51%	49%	51%	49%	49%	49%	49%

Fig 16, the 14 tools with similar score patterns. (Appendix B)

The following are the tools with similar tools:

Ideation Management Tool	Overall Score	Link
Mindmeister	51%	https://www.mindmeister.com/
Lucidspark	51%	https://lucidspark.com/
Mural	51%	https://mural.co/
FigJam	51%	https://www.figma.com/
Adobe XD	49%	https://www.adobe.com/dk/products/xd.html
Whimsical	51%	https://whimsical.com/
Canva	51%	https://www.canva.com/en_gb/
Miro	51%	https://miro.com/
MindView	49%	https://www.matchware.com/mind-mapping-software
XMind	51%	https://www.xmind.net/
IdeaFlip	49%	https://ideafliip.com/
Stormboard	49%	https://stormboard.com/home
Bubblus	49%	https://bubbl.us/
Mind24	49%	https://mind42.com/

Last retrieved Aug 2022

The similar scoring patterns, and overall scores suggests that all of these are a certain type of tool, dissimilar to the other tools on the list.

I have dubbed these *Ideation Management Tools (IMTs)*. I found IMTs to offer a great deal of customization, precision and expression - empowering the attributes of emphasis and pattern recognition, two of the main attributes of a good Mind Map and visualization of ideation (Buzan, 1996). However, IMTs are all lacking in offering external assistance in the *thought processes*. Moreover, if the user is not capable of utilizing the tools' many attributes such as, plugin, connectors, shapes, colorschemes, copy-pasting etc. the tools abilities and uses are not much different from that of pen and paper. The multitude of possibilities and purposes of the IMT complicates the UIs of the tools. This shifts the agency to be effective to

the user, and the tools are as such less likely to be used efficiently, than tools that can ensure the efficiency inherently in their design. This is not to discredit or dismiss the effectiveness of IMTs. They are popular for a reason after all - granting a single designer, or design team, a digital platform for applying their ideation techniques.

My review shows an abundance of both paid and free IMTs (Appendix B). In fact, I stopped including IMTs that do not offer externally generated content, after the first 15 were put on the list, as it was a seemingly endless stream. I contribute this to my definition not excluding tools without externally generated content. I did not include that limitation however, because the top six ideation tools for designers are part of IMTs (Taylor & Jordan 2021), and as such are the de facto commercial type of CSTs for ideation.

While some of the IMTs are also tools for wireframing/prototyping digital applications - the popularity suggests a big interest in web based software for ideation. This is further backed up by Design Tool Survey 2021 (Taylor & Jordan 2021) that shows Mural, Figma, Miro, Whimsical, FigJam and Adobe XD to account for almost all facilitation of digital ideation - designers are spoiled for choice it seems. What these findings show is a lack of tools to not only facilitate ideation techniques, but to make ideation techniques an inherent part of the tool's design. There are few tools that aim to relieve the user of having to apply and be experts in the techniques.

Key findings in the review

- *None of the found tools fulfills all of the design aspects for an ideal digital CST for solo ideation.*
- *There is a prevalent certain type of tool, the ideation management tools (IMT), which is at least 67% of the commercially available tools - and best suited for collaborative ideation.*
- *Only one tool could avoid Mode 2 of thought (design aspects 3). The others rely on the user's experience and expertise to do so*
- *Most of the reviewed tools have no inherent way of breaking design fixation (aspects 5,6, & 7), and thus relies on the user's experience and expertise*

Three of the reviews; specified

I now specify three different tools' reviews to triangulate pitfalls of different implementations of solo ideation in digital CSTs.

While I have had my hand on, and reviewed all tools on the list - I have not written out explanations, arguments or discussion of my scoring in detail for every tool. I have, however, written the reviews in full detail for three of the tools. Specifically, the next part of this chapter is the scoring of Mural, Generateideas.ai and VisuWords explained in detail. The purpose of the specific reviews are:

- 1) *to show my ability to review tools in accordance with the design aspects and methodology described*

2) triangulate issues of implementations in digital CSTs in regards to solo ideation. The three tools differ from one another as to cover a broad spectrum of the found tools.

Mural is a representative of IMT, GeneratIeas.ai is chosen as it is the highest scoring tool overall, and VisuWords is chosen as a representative of a tool that offers external information, structured visually by the tool, and not the user. The reviews of the specific tools led to findings on practical implementation issues to avoid in digital CSTs for solo ideation, due to their effect on one or more of the design aspects required of a digital CST for solo ideation.

Review of Mural:

	Mural
	https://mural.co/
Is the tool digital reliant?	4
Does the tool stimulate pattern recognition?	3
Does the tool avoid Mode 2 of thinking?	2
Is the tool usable by a single user?	5
Does the tool offer external information?	1
Does the tool offer relevant information?	0
Does the tool offer continuous ideation?	3
Score	15
Succes%	43%

Fig 17, Mural's review score. Appendix B

Description:

I have chosen Mural to represent the IMT in the review, as most of the findings on this tool specifically, are applicable to the other IMT in various degrees. Mural is a prevalent commercial digital CST, as evident it's the widespread use. (Taylor & Jordan 2021) The interface is shown in fig 18.

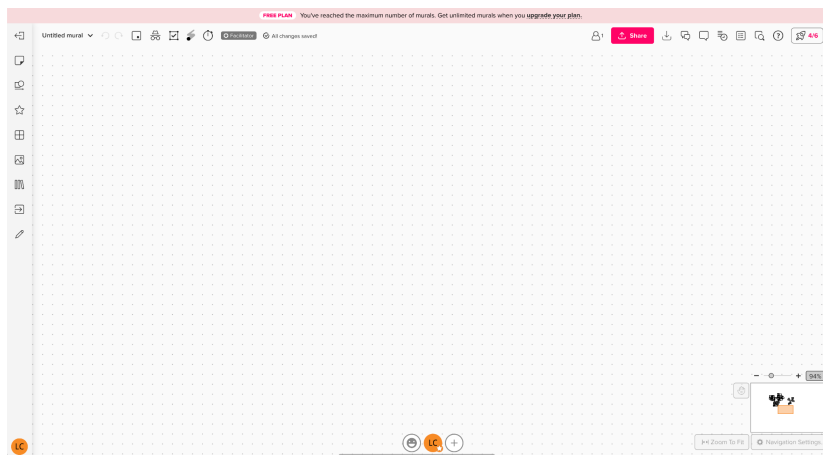


Fig 18. The interface of Mural

Is the tool digital reliant? 4/5 *Mostly Yes*

While Mural relies on digital technology, it doesn't reach full score (5) in this aspect. The reason is that a user can use Mural in a way that is not digital reliant. I show this in fig 19.

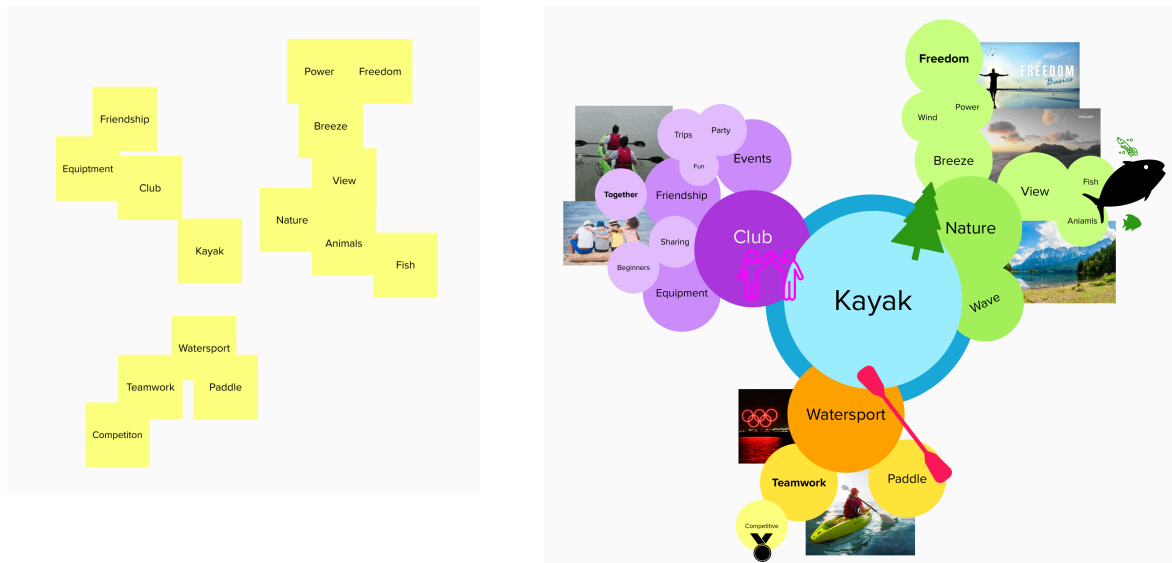


Fig 19, example of two different 10-minute ideation sessions in Mural. (author 2022, via Mural.com)

Left is a session easily recreated with analog tools, and right is a session that uses Murals built-in search engines, pictures, GIFs and digital visual aids such as fonts, colorschemes, shapes, iconography, precision etc. The latter session is not *impossible* to recreate analog, but *very* cumbersome and on the verge of improbable. Mural does have many benefits of the digital world, but requires interaction and some experience from the user to take advantage of those - and with no way to ensure the digital aspects are utilized, the answer to “*Is the tool digital reliant?*” must be “*yes mostly*”.

Does the tool stimulate pattern recognition? 3/5 Somewhat yes

The answer on this is *somewhat yes*, as it is up to the user to utilize Mural to do so. There is no automation whatsoever to guide the pattern stimulating proces. But as Mural comes with built-in connectors for shapes, and templates to guide patterns of brainstorming and Mind Mapping, automating *some* of the process - it is obvious that the user is guided towards pattern recognition. Because of this, the verdict falls on *somewhat yes*.

Does the tool avoid Mode 2 of thinking? 2/5 Somewhat no

Mural has a wide variety of attributes, multiple features to understand and has no automated processes for creative thought. It is possible to create Mind Maps and other techniques to avoid mode 2 of thinking, just as an analog whiteboard or piece of paper or the like. The *graphical user interface (GUI)* of Mural, fig 20, is another element that requires the user to enter Mode 2 of thinking instead of the desired Mode 1.

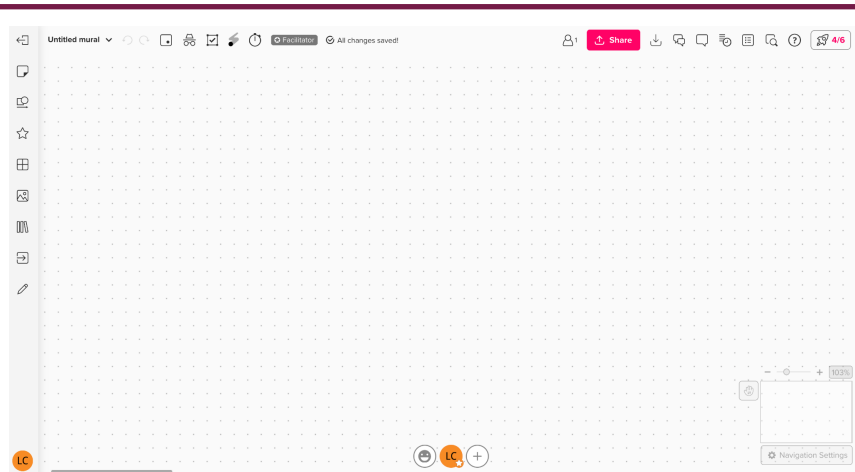


Fig 20, GUI of Mural (Mural.com, 2022)

The minimalistic GUI consists of a side menu, header menu, minimap, participant icons and two scrollbars. The tool has at least 39 different interactions on this first *blank canvas* screen. As seen in fig 20, menus are based on iconography. The icon based menus arguably makes *learning* the tool harder, needing exploration or tutorials, but once learned, is less demanding on the brain than text based menus (Gittins 1986; Gatsou et al. 2011). So while the capabilities of the tool to avoid mode 2 of thinking is apparent, it relies heavily on the user's actions, experience and knowledge of the tool and usage - the answer is not a definite no, nor a *mostly no*, but a *somewhat no*.

Is the tool usable by a single user? 5/5 Yes

Yes. Even though collaboration is available, the single user experience is almost the full experience, apart from features such as “comments” and “video conference”.

Does the tool offer external information? 1/5 Mostly no

There are built-in image and icon search engines, allowing the user to drag accessible through the side bar, and 3rd party software to add more search engines and filters. The tool streamlines access to images and iconography on the web, and somewhat filters it (in regards to what search engines they use etc.). This feature is a small-scale version of any other web search by the user. So while Mural is not designed to suggest or offer external information, the tool is at least making an effort to lessen the effort to find your own external information to utilize within Mural.

Does the tool offer relevant information? 0/5 No

No part of the tool's design can ensure relevance in the information presented.

Does the tool offer continuous ideation? 3/5 Somewhat yes

As with some of the previous aspects, this is up to the user. There are small features such as hotkeys and templates to expand on topics, and as I have not identified any traits to stifle continuous ideation, the verdict falls on *somewhat yes*. The reasoning for not scoring Mural higher in this regard, is the fact that the continuous ideation is not integrated in the design and relies on the user to take advantage of custom made templates and their own technique application.

Scoring

The aggregated score of Mural, ends up being 18 of 35 points - meaning 51% success.

Discussion on Mural

I recall my definition of ideation as the *formalized divergence of thought, for the purpose of generating ideas*. As ideation contains a *formalized* portion, the notion lends itself to be managed in some sense or another. This is why ideation can be taught; as it is not just inherited thought of a person, their intuition or talent - but it's also the structure of methods, techniques and tools that together make up ideation (Rawlinson 1981, Couger 1996, Andersen 2005). In this regard, Mural, and IMT in general, seems to fulfill their supposed goal as being a platform to create the structure for ideation, managing the process - but not *directly* supporting *thinking up ideas*.

Another point of interest in this review is the collaborative element of IMT. 12 of the 14 IMT on the list, actively promotes collaboration in their marketing or UI. I contribute the IMT overall dominance in the market (Palmer 2019, Taylor & Jordan 2020, 2021) to this fact - that the need for structure in ideation is immense when collaborating (Adair 1996).

Review of Generateideas.ai:

B	R
ATTRIBUTES	
	Generateideas..
	https://www.gene
Is the tool overtly digital?	5
Does the tool stimulate pattern recognition?	4
Does the tool offer continuous ideation?	5
Is the tool usable by a single user?	5
Does the tool avoid Mode 2 of thinking?	2
Does the tool offer external information?	5
Does the tool offer relevant information?	5
Score	31
Success%	89%
Max avail score 35	

Fig 21, Scores of Generateideas.ai, appendix B

Description:

Generateideas.ai is “the world's first artificially intelligent brainstorming tool” (Generateideas.ai 2022). It is a part of the Ayoa digital platform, and as such integrated into the IMT developed by Ayoa, shown in fig 22. So while it is possible to use this platform without the AI, I base my review on the use of the Generateideas.AI feature within the tool.

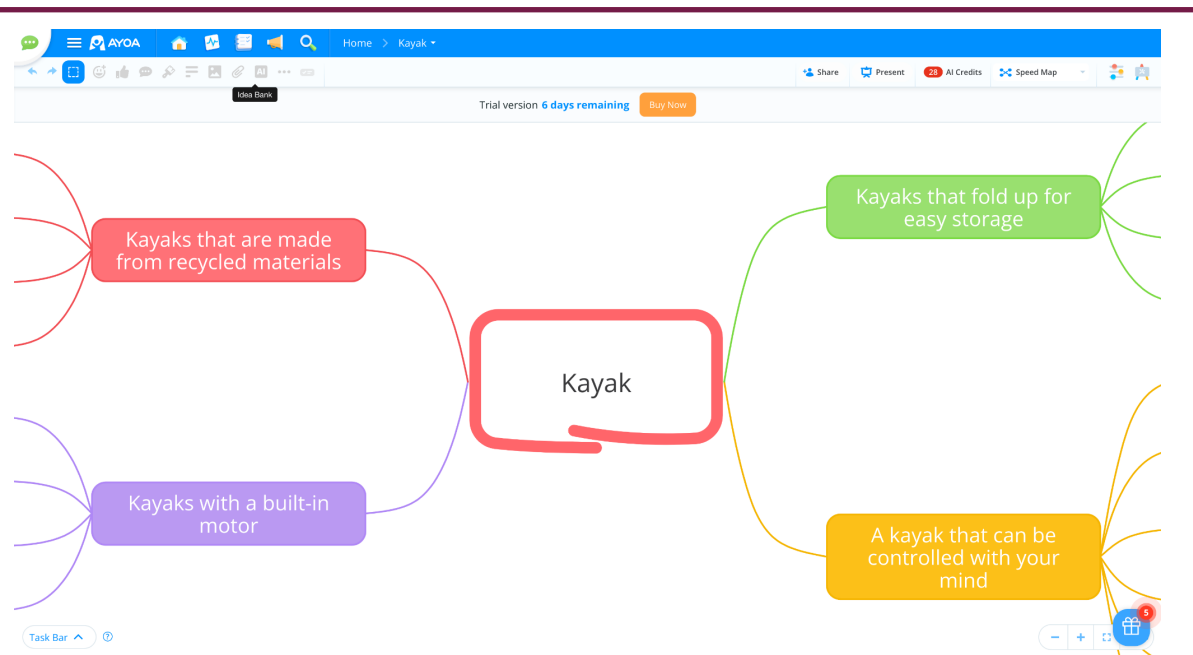


Fig 22, Generateideas.ai in the Ayoa platform, with Kayak as first prompt for a BrainStorm.

Generateideas.ai looks and works a lot like most IMT. But an interesting, and as far as i can tell, unique feature, makes the tool stand out from the rest. The tool utilizes artificial intelligence to come up with either ideas, questions or an explanation of a selected node (Generateideas.ai 2022).

Is the tool digital reliant? 5/5: Yes

Utilizing AI and a self-claimed 10% of the internet to base the neural network on (Medlicott 2011, blogpost by Ayoa) there is no doubt this is a digital reliant tool.

Does the tool stimulate pattern recognition? 4/5 Mostly yes

The pattern recognition is particularly strong in the automated color coding, and the automated connectors in the branches. It does not get the full five score, as the pattern lacks more emphasis, personalization and imagery.

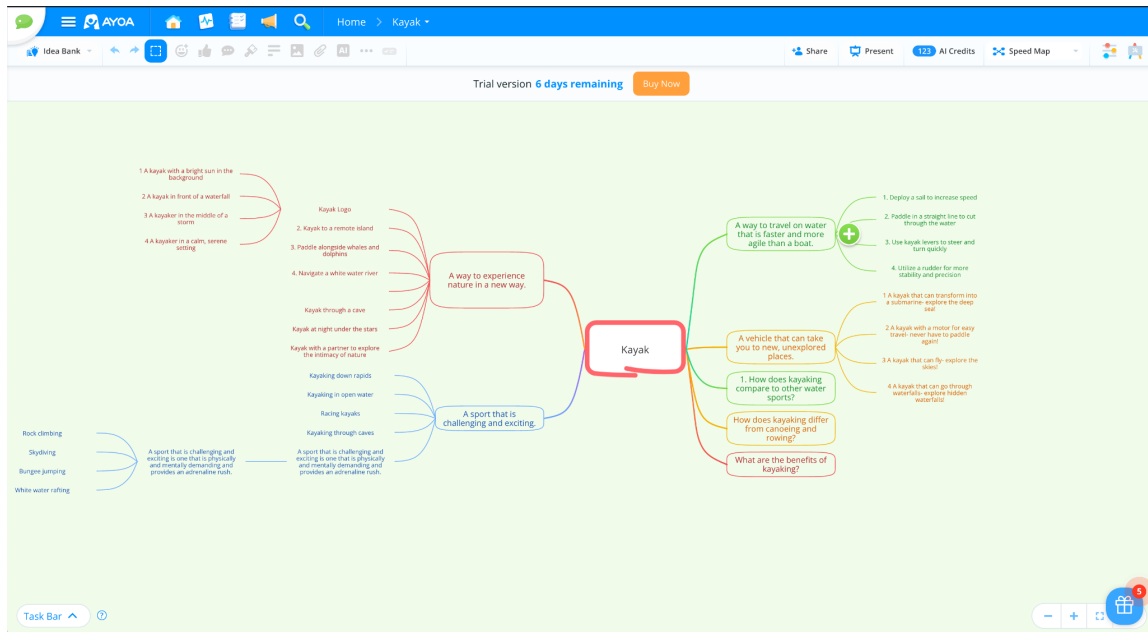


Fig 23. A mind map in GenerateIdeas.ai powered by Ayoa (screenshot 2022)

Does the tool avoid Mode 2 of thinking? 2/5 Somewhat no

As seen in fig 23, the tool, like many other IMT offers a wide variety of opportunities for the user. Two header menus, a popup bar and the “gift” notification does not help the brain avoid mode 2 - they are all distractions. Furthermore, the absolute key feature, the big selling point, the self described “... world-exclusive, AI-powered way to superpower your mind maps to a genius level” (Medlicott 2021, blogpost by Ayoa) is hidden behind several clicks. To utilize the AI, the user must right click the node they wish to have the AI help with, then find the AI button, then select what AI feature to utilize and then select what quantity of AI generated nodes should spawn. (Fig 24)

There are no hotkeys to access the feature, nor is it accessible using the TAB key, as that is bound to node creation in the software. This means at least four clicks, all in need of the user's ability to aim the mouse, is demanded to access the feature at the core of the software. The toolbar at the top can be customized, but this will only reduce the clicks to three, and increase the range in which the mouse pointer and the eyes of the user has to move from the selected node to the toolbar at the top of the GUI.

While these observations might seem trivial, clicks, aims and mouse usage is of importance regarding cognitive load (Omanson 2010; Miller et al 2011).

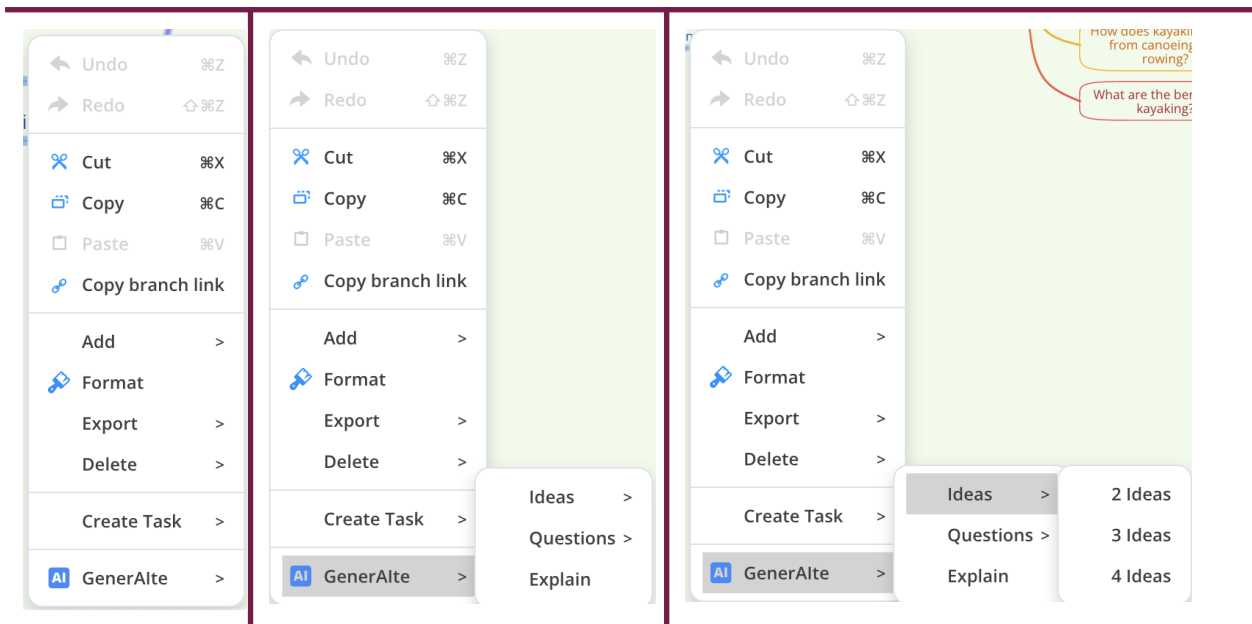


Fig 24. Where the AI feature is 'tucked away' in the GUI, in three steps, from left to right.

Based on *selection categorization* (Omanson et al 2010), I argue that the usage of the feature requires the following step of the user:

1. Decide which node to explore
2. Look for node
3. Point to node
4. Click mouse
5. Look for item
6. Point to item
7. Wait for mousehover to expand item
8. Look for item
9. Point to item
10. Wait for mousehover to expand item
11. Look for item
12. Point to item
13. Click mouse

Relating back to thinking modes - Goldschmidt (2016) describes Mode 1, our desired way of thinking in the context of ideation, as defocused. I argue that the thirteen steps to activate the feature of AI, does not help the user defocus. On the contrary the GUI and interaction actually require attention and focus from the user, counteracting Mode 1 by promoting Mode 2.

If the selection of the AI features, and GUI itself wasn't enough to put Generateideas.ai into *somewhat no* in the avoidance of Mode 2 of thinking, there is another element that makes the user stray from divergent thinking. The nodes offered by the AI are meant to be *read* - taking focus from the creative thought. This however is a double-edged-sword: the reading itself requires the user's brain power, but the content of the nodes should be prompt for divergent thinking. Questions generated by the AI can be used as a source of inspiration for

further ideation by the user. (Fig 25) This does however rely on the user, as the software is no different from other IMT in this regard.

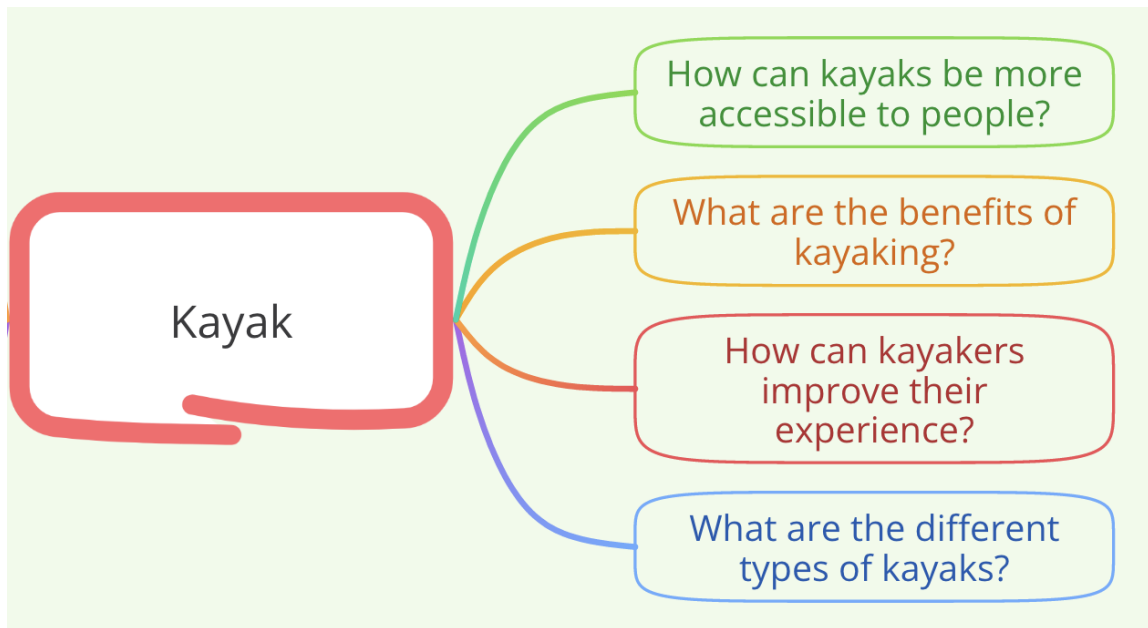


Fig 25 Questions posed by the AI concerning the notion “Kayak”

As seen in fig 25, the questions posed will diverge the ideation into different directions, that then might open up new possibilities. Open-ended questions like these are ideal to spark divergent thinking (Couger 1996 p.87). So while the AI is a powerful provider of prompts in this regard, the further facilitation of divergent thinking in the tool is similar to other IMT - failing to facilitate fast paced and defocused thinking. Generateideas.AI does however try to eliminate it altogether. With the feature of AI generated ideas (Fig 26), the user might not even need to diverge their thinking that much.



Fig 26. AI generated ideas based on user generated prompts.

The feature does show slight differences in how one prompts the tool though, as each prompt, and each time the prompt is used, yields different results. As with any AI, the algorithms and neural networking is a black box, and with self claimed 180 billion parameters inside of the neural network (Medlicott 2021, blogpost by Aoya) it is impossible to predict the output. I wonder if this feature would be of better use in another technique, rather than a Mind Map that is designed for Mode 1.

Is the tool usable by a single user? 5/5: Yes

Yes.

Does the tool offer external information? 5/5: Yes

Yes, the AI offers external information.

Does the tool offer relevant information? 5/5: Yes

Yes, the AI offers relevant information. It is however not accessible to know the sources, and as such the bias of the software is unknown.

Does the tool offer continuous ideation? 5/5: Yes

While there is a credit system in place to limit free access, if a user spends money to unlock the limitless feature, the potential use is endless.

Review of VisuWords:

ATTRIBUTES	Visuwords
	https://visuwords
Is the tool overtly digital?	5
Does the tool stimulate pattern recognition?	2
Does the tool offer continuous ideation?	5
Is the tool usable by a single user?	5
Does the tool avoid Mode 2 of thinking?	1
Does the tool offer external information?	5
Does the tool offer relevant information?	4

Fig 27, Scores of VisuWords, appendix B

Description:

VisuWords is an aptly named tool to visualize words, utilizing a word database from Princeton University (Princeton University 2010). The user can input a word, and see related words, with relations visualized in different ways - and a decipher index to understand the visualiations. fig 28 shows the interface.

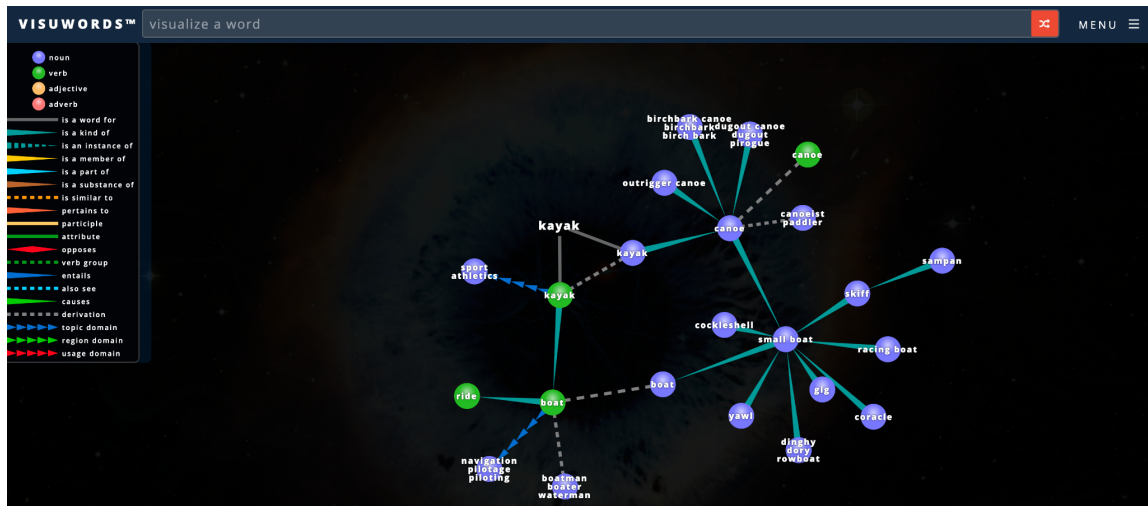


Fig 28, VisuWords opened in the browser, with “Kayak” as input. Screenshot, 2022

The user can then double click any node to expand the node and see words related to that, and thus a web evolves. One thing that can't be seen in the screenshots is the motion of the web; the nodes are animated as *bubbly* and floating around. Pressing a node will make the newly spawn nodes, along with the whole web, float and bounce into new places. Even when not interacting, the nodes will gently bob up and down.

Is the tool digital reliant? 5/5: Yes

The tool takes advantage of a large lexical database of the English language, with 155.327 unique words (Princeton University 2010). The instantaneous and presumably correct relations shown between those words in VisuWords is overtly digital reliant.

Does the tool stimulate pattern recognition? 2/5 Somewhat no

While the tool presents a pattern, this is distinct from *pattern recognition*. This is similar to presented notions of concepts maps versus mind maps. While a concept map, as VisuWords can be interpreted as, is good for representing subjects in a visual way - it is a technique that aims to make a *readable* visualization: to get an overview of a subject. This is Mode 2 of thought that analyses, calculates and focuses, to extract meaning. Pattern recognition found in mind maps however, are fast-paced associative patterns, meant to be intuitively interpreted, to extract meaning: ideal for Mode 1 of thinking. In this sense, VisuWord does not stimulate pattern recognition as laid out in this work.

Does the tool avoid Mode 2 of thinking? 1/5 Mostly no

The decipher index of VisuWords, required to understand the meaning of the visualization presented by the tool. (Fig 29)

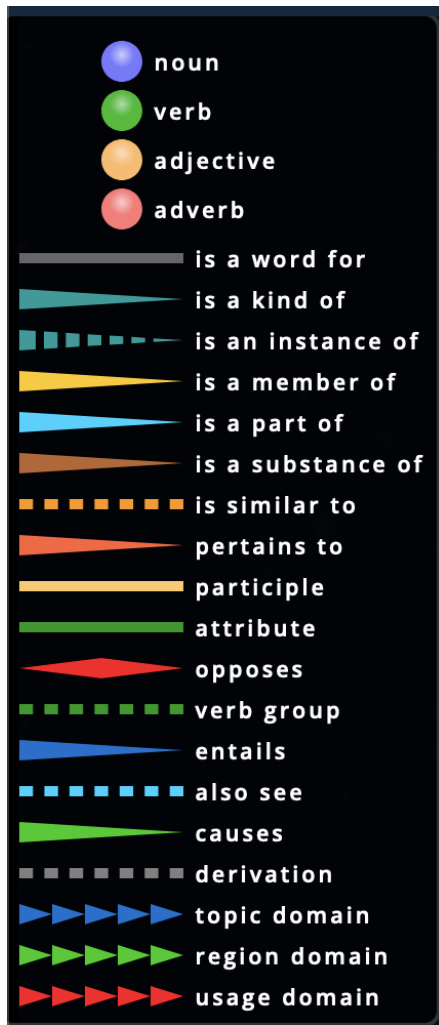


Fig 29, the decipher key needed to understand the visualization of Visuwords

This is facilitation of mode 2 of thinking, as it requires attention and focus, memory and is rule-based. Maybe, if an expert user can hold the decipher index in the head and use it to easily understand the visualization it would help to move the thinking into mode 1. Further, there is no check and balance of the input. As an example. Pressing “sports athletics” *exploded* in more than 40 nodes, as seen in fig 30, making it implausible for the visualization to convey any meaningful fast-paced deciphering of the notions presented.

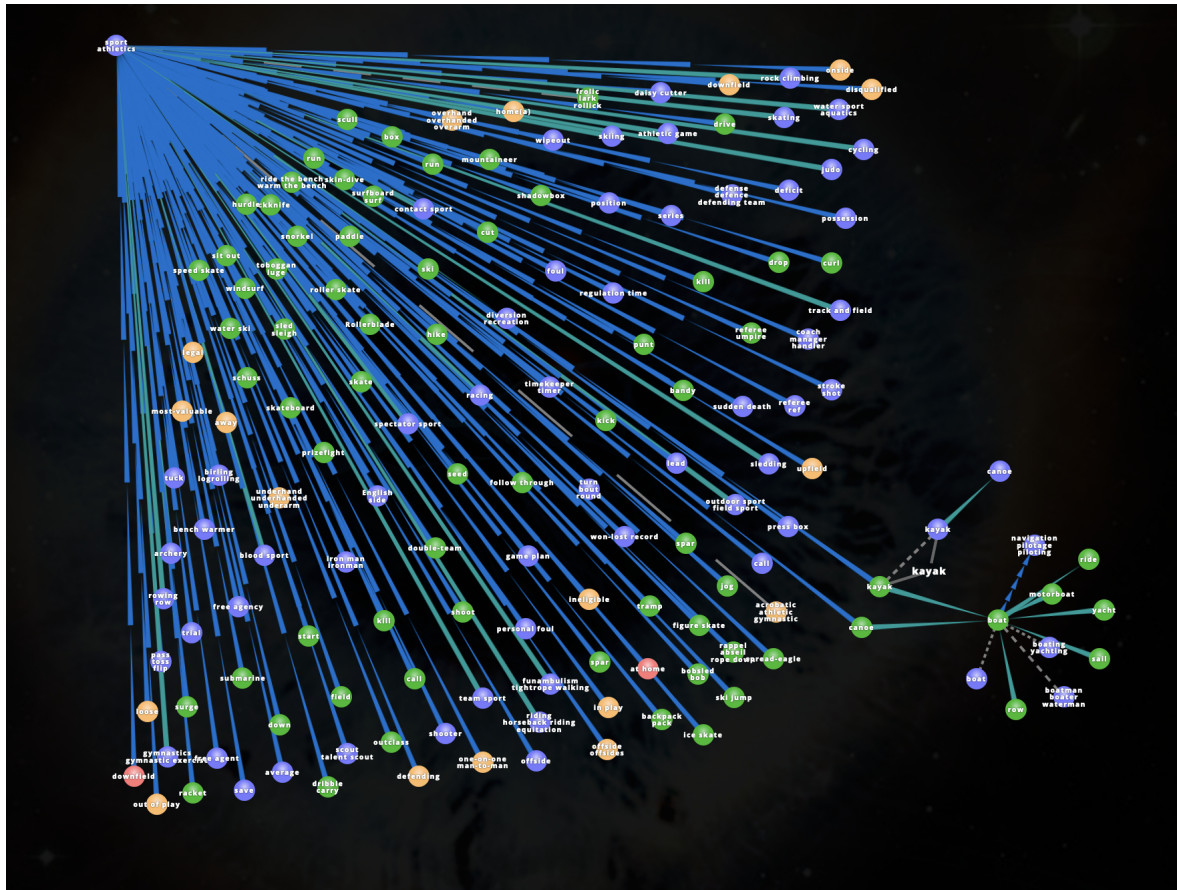


Fig 30, the *explosion* by pressing *sports athletics* in VisuWords

If the intention is the categorization, analyzing and understanding of certain words in a sense of lexicography - I assume there are more effective ways to convey the facts. If the intention is to easily convey connections and relation between words, more mode 1 thinking should be applied.

Is the tool usable by a single user? 5/5: Yes

Yes, it is meant for a solo user only.

Does the tool offer external information? 5/5: Yes

Yes. Each click exposes nodes

Does the tool offer relevant information? 4/5: Mostly Yes

This is obviously dependent on context, but assuming one works within the scope of words and lexicography, the information is relevant. But seeing as words presented can be the same words as previous, or almost same but with different conjugation - seemingly redundant information if not utilized specifically for that purpose, I would say that it is *Mostly* Yes, and not the full Yes.

Does the tool offer continuous ideation? 5/5: Yes

Yes. Any word can expand to new words - and with a collection of more than a hundred thousand words, the expansion seems endless.

Key findings in specified reviews of implementation

The following are specific implementations issues, found in one or more of the chosen tools, that affects the success of a digital CST for solo ideation:

- Cluttered GUI
- Overwhelming amount of options in the tool
- Slow menu selections
- Slow menu deciphering
- Making the user *read* the visualization
- Reliance on the user's expertise in ideation techniques
- Reliance on the user's expertise in visualization
- Irrelevant external input

Summary of review

The review clearly shows that none of the reviewed tools are ideal for solo ideation, in the sense that is laid out by my analytical work. The review further reveals that the 2007 quote from Thomás Dorta seems to still hold up:

“The discrepancy between the creative impulse and the input needed to activate digital commands often leaves the designer bound to a process that steers him away from design thinking [in this thesis: Mode 1].”

- Dorta 2007.

This is apparent in how the scores of *Avoidance of Mode 2* are low scores, reflecting the input needed as an input that stifles Mode 1 of thinking. The tools reviewed seem to be built for a structured, and somewhat *slow* creative process - that is the opposite of what is best for the solo ideation, but rather what is needed for collaborative ideation. As such the review has revealed a clear blank space in commercial tools for ideation; they do not facilitate solo ideation well.

Chapter 5: Discussion

In this chapter, I discuss the methodology's benefits and limitations, and then go on to discuss the broader impact of this thesis in the field of digital CSTs for solo ideation.

Review methodology

It does stand to reason, that working on specific aspect requirements for a CST, is at a risk of reinventing the wheel as described by Frich et al:

“Creativity-oriented HCI [Human-Computer Interaction] research tends to favor the design and development of all-new CSTs. This approach may entail the risk of ‘reinventing the wheel,’ since closely related, or similar, CSTs might already have been developed [...]”

- (Frich 2019 page 389)

But my intentions are not to create an all-new tool in a manner of implementation, nor is it to give specific recommendations on how to *implement* aspects. The intent is rather that researchers and designers alike can utilize these design aspects to further develop, evaluate and investigate the field of digital CSTs for solo ideation. That is the main benefit of this methodology; creating valid arguments to evaluate digital CSTs in their ability to afford solo ideation.

What ultimately is missing is a form of validation of the design aspects - be it setting up an experiment or other independent studies of the matter. Making others review the tools utilizing the aspects, might reveal misunderstandings, or wrong conclusions of the aspects. Validating the aspects in regards to their accuracy to evaluate solo ideation efficiency, would require experimenting with solo ideation by multiple users, collaboratively and solo, in multiple of the selected tools - to then compare to the reviews and see whether or not the results reflect each other.

What is the impact of the thesis?

One of the needs of this thesis is to lay out the foundational work necessary to conduct an evaluation of existing digital CSTs in regards to solo ideation. This needs to be addressed, to make aspects to evaluate digital CSTs. The purpose is to specify what problems the implementation of a digital CST for solo ideation needs to solve. This process is an integral part of most design processes, and similar phases are seen with the following practitioners.

Discover and define in the double diamond by Design Council (2005)

Discover and interpret, as described by Torreblanca et al. (2019)

Empathize and define in design thinking, as laid out by Dam and Siang (2022)

I show how the work of this thesis can mirror the initial design process, if one were to design and implement the ideal digital CST for solo Ideation, in fig 31.

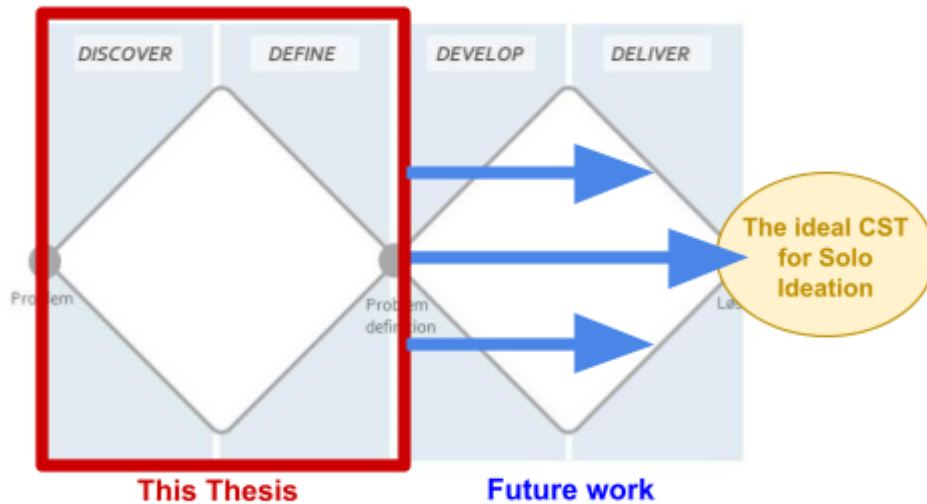


Fig 31, the role of this thesis; as seen through the lens of Double Diamond by Design Council (last retrieved 2022), overlay in red, blue and yellow by me

The work of the thesis has firstly unraveled the many terms and concepts of CSTs and created seven broad aspects to consider in designing a digital CST for solo ideation. That work is necessary to talk about and understand digital CSTs for solo ideation. Applying the work in my review, I show that there is not just a blank space in commercially available tools, or missing tools for solo ideation - but that the popular and widespread tools have attributes and implementation issues that are directly counterproductive for solo ideation.

To elaborate, I present the three main contributions of this thesis:

- Identification of blank space in commercially available tools for solo ideation
- Seven design aspects for evaluating digital CSTs for solo ideation
- Clearing up terminology in the field of HCI and CST

Identification of blank space in commercially available tools for solo ideation

The presented review of commercially available tools, reveals the popular and widespread type of tool; the *ideation management tools* (IMT). My work points to a discrepancy between the existing digital CSTs and the ideal digital CST for solo ideation. On this basis I argue that I have shown that most digital CSTs used in ideation commercially are more suitable for collaborative ideation than solo ideation. With this I believe to prove merit for further research and development of a digital CST directed at solo ideation.

Seven design aspects evaluating digital CSTs for solo ideation

My design aspects for the ideal digital CST for solo ideation is the result of analysis of a multitude of theories and concepts within CSTs. With each aspect, I partly conclude what is optimal for solo ideation in a digital tool. Based on results from the presented reviews, that

utilize the design aspects for their basis of evaluation, it seems a fair conclusion that the aspects are useful for evaluating designs.

Clearing up terminology in the field of CST

Another impact of this thesis is my refinement of definitions in the field of digital CSTs. I conclude that the field lacks common terminology and coherence of definitions. I found the terms *creativity*, *ideation*, *tool* and *value* to be crucial for understanding CST. I contribute by proposing my definitions to understand and apply the terminology. I further conclude that a *tool* will inherently affect the *technique* and thus *method*, and as such, picking the right CST is of importance for any creative method.

Chapter 6: Conclusion

This thesis revolved around the following research question:

How well is solo ideation supported in commercially available digital creativity support tools?

My answer to this is that; *solo ideation is not sufficiently supported in commercially available digital creativity support tools*

In fact, the review conducted, showed that the existing tools were mostly *Ideation management tools*, requiring Mode 2 of thought (aspect #3), and did not inherently offer means of breaking *design fixation* (aspect #5, 6 & 7) - thus relying on the user's experience and expertise in ideation, or on collaborative inputs. This is the opposite of what an ideal digital CST for solo ideation should be aiming for.

This presents a new question on *how* the aspects presented, should be implemented - but that is a question for another type of study. I am hopeful and confident that this thesis can serve as the foundation for such study, as I have now defined the problems to solve for an ideal digital CST for solo ideation.

Chapter 7: Future works

Validation

There are two matters to be validated; the aspects themselves in regards to solo ideation, and my reviews of the existing tools. Confirming my work, in an experiment of the reviewed tools would be valuable further work. Testing with novice users and expert users, solo and collaborative ideation, would prove or disprove my findings and aspect proposals. Another way is as proposed in my discussion; having others review the tools with the same methodology as me, to see if their results mirror my own.

Implementation

As explained previously, this thesis serves as the foundational work of the development and evaluation of digital CSTs for solo ideation. Further studies on the impact of specific *features and implementations* of digital CSTs is recommended. It seems popular to study the effect of creativity techniques, (Svensson & Taghavianfar 2015; Biskjær et al 2017), yet I believe more work should be conducted into the tools of creativity, rather than techniques. Action cards presented in my appendix A are made for this purpose. Another approach to this matter is to develop a tool, or a plugin for an existing tool, that aims to implement features that can fulfill the design aspects I present - to then test that tool for solo versus collaborative ideation.

AI Ideation

Further there is the aspect of AI ideation. I did not anticipate AI ideation to be as beneficial as it seemed to me; It removed much of the strain of ideation, and took over the creative process by posing questions and ideas. This premise, that the computer can take command of the ideation in a hidden process is wild to me - eliminating the need for creativity substantially.. Studies in that aspect should be conducted as it is a groundbreaking premise, but hidden away in a drop-down menu of a not-commonly-used tool.

Thank you for reading
- Lars P Jerichau Clausen, 2022

Litterature & citations

Scientific publications:

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Graphics:

Figure 2 Design process phases based on Design Thinking process for educators (IDEO & Riverdale, 2012). Drawing by Catalina Grellet De Los Reyes.

Figure 3. Design Funnel – schematic overview of our design process. Adapted from (Buxton 2010, p. 148; Pugh 1991, p. 75)

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