

ACTIVATING CONCENTRATED CURIOSITY IN PROBLEM CONSTRUCTION TO ENHANCE CREATIVE PROBLEM SOLVING

AN INVESTIGATION OF ALTERNATIVE APPROACHES TO
PROBLEM FRAMING AND INFORMATION SEARCH AND
THEIR EFFECT ON THE CREATIVITY OF RESULTANT
SOLUTIONS

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ABSTRACT

Activating concentrated curiosity in problem construction to enhance creative problem solving

An investigation of alternative approaches to problem framing and information search and their effect on the creativity of resultant solutions

As the first stage in the creative problem solving process, problem construction plays a pivotal role in facilitating the creativity of solutions generated. This thesis develops a theory that proposes an approach to optimise two sub-stages of problem construction, namely, the information search and problem framing, and subsequently builds a normative framework based on this theory to provide practical, evidence-based guidelines to improve the effectiveness of creative problem solving in organisations. To date, research into approaches to search for information about the problem has received little attention, and approaches to effectively frame a problem prior to generating solutions are still debated. Furthermore, research findings have not been leveraged to inform an evidence-based normative framework. This thesis comprises four papers. In paper one, the theory is developed based on literature research. In paper two, the theory is tested experimentally by exposing four groups of senior managers in a large financial services company to different experimental conditions and then comparing the creativity of solutions generated using two different approaches to the information search and two different approaches to problem framing. The development of a normative framework in paper three draws on both the theory and experimental findings. In this paper, in-depth interviews are also conducted with problem solvers from various disciplines to test the applicability and relevance of the framework developed to address the information search. The effectiveness of this normative framework is tested in an action research study in paper four, and findings are used to refine the framework and implementation guidelines. This study also serves as a second field test of the theoretical model.

INTRODUCTION

In a highly competitive age, in which technological developments and instant communications are resulting in ever mutating and increasing customer expectations, creativity and innovation are essential for businesses to maintain and grow their customer base and revenue streams. Innovation has therefore been widely adopted in organisations' mission statements (Amabile & Pratt, 2016). Moreover, there has also been increasing recognition of the necessity for the application of creativity in growing and sustaining economies and resolving societal challenges, especially in the face of globalised markets, the increasing sophistication and role of technology, as well as the associated threat of routine or non-creative work being automated or outsourced to artificial intelligence (Sawyer & Henriksen, 2024). In this context, the question of how to enhance creativity and innovation is arguably more relevant than when research into this field began in the early 1940's (Isaksen & Treffinger, 2004).

As outlined in this introduction (see Section 1.2 below), in seeking to answer the question of how to improve an organisation's capacity for creativity and innovation, there is value in distinguishing between innovation, creativity and creative problem solving, as the creative problem solving process provides a structured model that lends itself to targeted investigation, such that findings can be actively applied to enhance its effectiveness. This is the focus of this thesis.

This thesis sets out to explore alternative approaches to problem construction within the creative problem solving process – namely by exploring two potential approaches to the information search and two potential approaches to the problem framing - and to propose a novel theory of problem construction. It subsequently develops a normative framework for problem construction based on this theory.

In this introduction to the thesis, terms used are defined and the proposed contributions, as well as the rationale behind it, are introduced. The structure of the thesis is then laid out.

1 DIFFERENTIATING BETWEEN INNOVATION, CREATIVITY AND CREATIVE PROBLEM SOLVING

1.1 Creativity versus innovation

Creativity has been defined as the production of ideas or solutions that are novel and useful (Amabile, 1988, 2018), and little argument emerges in the literature about the inclusion of the criteria of originality and utility in defining creativity (Barron, 1955; Runco & Jaeger, 2012). Definitions of innovation, on the other hand, invariably incorporate the element of idea implementation (Anderson, Potočník & Zhou, 2014). Singh and Aggarwal (2021) used grounded theory to derive their comprehensive definition of innovation as “the operationalization of creative potential with a commercial and/or social motive by implementing new adaptive solutions that create value, harness new technology or invention, contribute to competitive advantage and economic growth.”

While approaches to defining the distinction between creativity and innovation vary, it is well accepted that innovation at the organisational level depends on creativity. Given that it is the implementation of solutions to complex problems that constitutes innovation, creative problem solving enables innovation (Amabile, 1996a; Koen et al., 2002). In other words, “Simply put, without creativity, there is no innovation” (Puccio, Cabra, Fox & Cahen, 2010, p.153). Amabile and Pratt (2016) position creativity within the domain of individuals and groups, while they see innovation operating at the organisational level. Koen et al. (2002) described creativity as the ‘fuzzy front end’ of innovation, which is a description that communicates the essential role of creativity in the ubiquitous organisational value of innovation, as well as, probably unintentionally, the nebulous approaches organisations typically use to encourage creativity amongst employees.

For organisations looking to enhance their employees’ creativity, there is a growing body of literature on organisational innovation which attempts to understand the factors that drive and enable innovation, as it has become relatively well accepted that innate creativity is not an essential requirement for innovation, but rather that creativity is facilitated or hampered by many factors.

There is, however, a lack of practical, evidence based guidelines for optimising creativity, on which organisations can draw (Paulus, Dickson, Korde, Cohen-Meitar & Carmeli, 2016; Paulus & Kenworthy, 2018). This points to a gap in the translation of creative problem solving theory into practice. Further evidence of the gap between theory and practice is that whereas research findings clearly indicate the positive impact of organizational training in creative problem solving, there are remarkably few organisations in which formalised training in creative problem solving has been adopted in practice (Puccio et al., 2020).

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Reasons for failure in the practice of creative problem solving support this conjecture, as they highlight gaps between the world of theory and the real world of practice, in which creative solutions to complex problems are all too rare (Mumford, Martin, Elliott & McIntosh, 2020). Having reviewed the multiple causes of failure in creative problem solving in real world contexts, Mumford et al. (2020) go on to suggest the design of specific interventions that mitigate against the many potential pitfalls, arguing that while we have a reasonable understanding of the factors that facilitate creativity, we are not infallible in putting them into practice and need guidance in implementing approaches to creative problem solving. It is this gap between theory and practice that this study seeks to address.

1.2 Creative problem solving versus creative thinking

In this thesis, the term ‘creative problem solving’ is used rather than the more general term of ‘creative thinking’. The adoption of this term warrants some explanation. Guilford (1977) and Newell, Shaw and Simon (1967, as cited in Isaksen, 2020) saw creativity as a class of problem solving, but it can be argued that creativity can also be pursued for its own sake, such as in the arts, and is not always related to problem solving. Creative problem solving therefore refers to the deliberate application of creativity to solve a problem (Isaksen, Dorval, & Treffinger, 2011).

1.2.1 Problems that require creative problem solving

A rather broadly applicable definition of a problem which could benefit from creative problem solving is one in which “...a situation is in a given state, the problem solver wants the situation to be in a goal state, and there is no obvious way of transforming it from the given state to the goal state” (Mayer, 1990, p. 284).

Isaksen et al. (2011) also described problem solving as the process of converting a situation from the current to the desired state, but indicated that creative problem solving is only needed when the required solutions necessitate venturing into unknown territory. This implies that creative problem solving is not required to address all problems. Solving the problem of mislaid keys, for example, does not require creativity to establish their location. A problem to which creative problem solving should be applied is not a simple one that can be resolved by applying a bounded set of viable solutions. Rather, it is complex and ill-defined, such that it may include various role players, perspectives, potential for conflicts of interest, intangible factors and unpredictable elements (Hunter, Bedell & Mumford, 2006; Mingers & Rosenhead, 2004). While Mumford et al. (2020) define a problem that requires creative problem solving as not only complex and ill defined, but also novel, in this thesis the criterion of novelty is not applied, as it can be argued that many problems that are not novel, but rather long standing, could still benefit from the application of a creative solution.

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It should also be noted that complex and ill-defined problems that require creative problem solving do not always present themselves, but must frequently be proactively identified as opportunities to improve a situation. This is relevant in the organisational context, in which innovation is a consistent goal, such that problems should be actively and deliberately sought out (Basadur & Basadur, 2011).

The nature of problems that require creative problem solving therefore clearly represent opportunities for organizational innovation. Creative problem solving is consequently essential to address the constantly emerging, complex challenges of the inherently unpredictable, mutating environment.

1.2.2 Creative problem solving as a model of the creative thinking process

Creative problem solving has been defined as a “comprehensive cognitive and affective system built on our natural creative processes that deliberately ignites creative thinking and, as a result, generates creative solutions and change” (Puccio, Murdock, & Mance, 2007, p.29).

This definition implies that creative problem solving is an explicit model of the creative thinking process that allows for deliberate and systematic application of creative thinking to specific challenges (Puccio & Cabra, 2009). Modelling the creative process involves exploring and identifying the different thinking processes involved at each stage. This enables the development of approaches to optimise the thinking at each stage to facilitate both the identification and implementation of creative solutions to complex problems (Puccio & Cabra, 2010).

1.2.3 Potential for creative problem solving to be optimized to address opportunities for innovation

Against this background, the purpose for selecting the term ‘creative problem solving’ can be explained. Firstly, it pertains to the approach necessitated to address the type of problems that organisations inevitably face in a competitive, unpredictable environment, and which represent opportunities for innovation. Secondly, the structure and stages of creative problem solving models yield opportunities for research into approaches to optimize the effectiveness of the process. Yet while much research has been conducted to explore the enablers of and barriers to creativity, there are gaps in the literature regarding evidence based research on normative approaches in real world contexts. (Paulus et al., 2016; Paulus & Kenworthy, 2018).

It appears that the most common technique practiced by organisations to facilitate the generation of creative solutions to complex problems is brainstorming (Rietzschel, Nijstad, & Stroebe, 2006). However, this relatively unstructured, open ended idea generation technique developed by Osborn (1953), has been shown to be less than optimally effective (Heslin, 2009; Rietzschel et al., 2006, 2014).

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While Osborn was the originator of brainstorming, he developed this technique to serve as an idea generation tool, with idea generation being the second of a three stage CPS process (Osborn, 1963). The intention was therefore not to rely on this idea generation technique as a stand-alone process. In relying solely on this specific idea generation tool, organisations are not actively managing all stages of the process.

This development is understandable however, as process models in themselves do not provide implementation guidelines for managing and optimising the effectiveness of the process. Rather, they are "...intended to provide individuals and groups with an explicit creativity model that parallels how the mind naturally thinks". (Puccio, Cabra, Fox, & Cahen, 2010, p.154). While these descriptive models have been used for training purposes, there is a dearth of evidence-based normative frameworks specifically aimed at translating theory into practice (Paulus et al., 2016; Paulus & Kenworthy, 2018; Vernon, Hocking, & Tyler, 2016). The risk of developing normative frameworks that are not based on theory is that the practices that proliferate are not sufficiently robust. It is argued here that this is exemplified in the emergence of the design thinking methodology.

Conclusions that the combination of phases in design thinking can be distinguished from other methodologies (Liedtka, 2018) are drawn without any reference to the CPS methodology described above. Claims regarding the novelty of design thinking, such as have been made in alluding to the practice of continuing to look for alternative solutions (Liedtka, 2018), also do not acknowledge the vast body of academic literature on creative problem solving. It is argued that this example underscores the need to marry rigorous, empirically tested academic theory with practice.

2 RESEARCH OBJECTIVES AND PROPOSED CONTRIBUTIONS OF THIS THESIS

2.1 Research problem and objectives

This introduction provides a cursory critique of the literature, which is fully addressed in Paper 1. The gaps highlighted above however, point to the rationale for stating that **the research problem addressed in this thesis is the lack of detail in the research literature regarding optimal approaches to problem construction in creative problem solving**. While the literature does address the role of active problem construction, specific approaches that might be adopted in problem construction to enhance the effectiveness of creative problem solving, remain largely unexplored.

The overall research objectives of this thesis are therefore to develop a theory of optimal problem construction and a normative framework for its implementation.

2.2 Proposed contributions

This thesis sets out to make a theoretical contribution by way of the concentrated curiosity theory, which develops a novel theory of problem construction within the creative problem solving process. It addresses gaps in the literature regarding the information search and incorporates an integrated theory of problem framing.

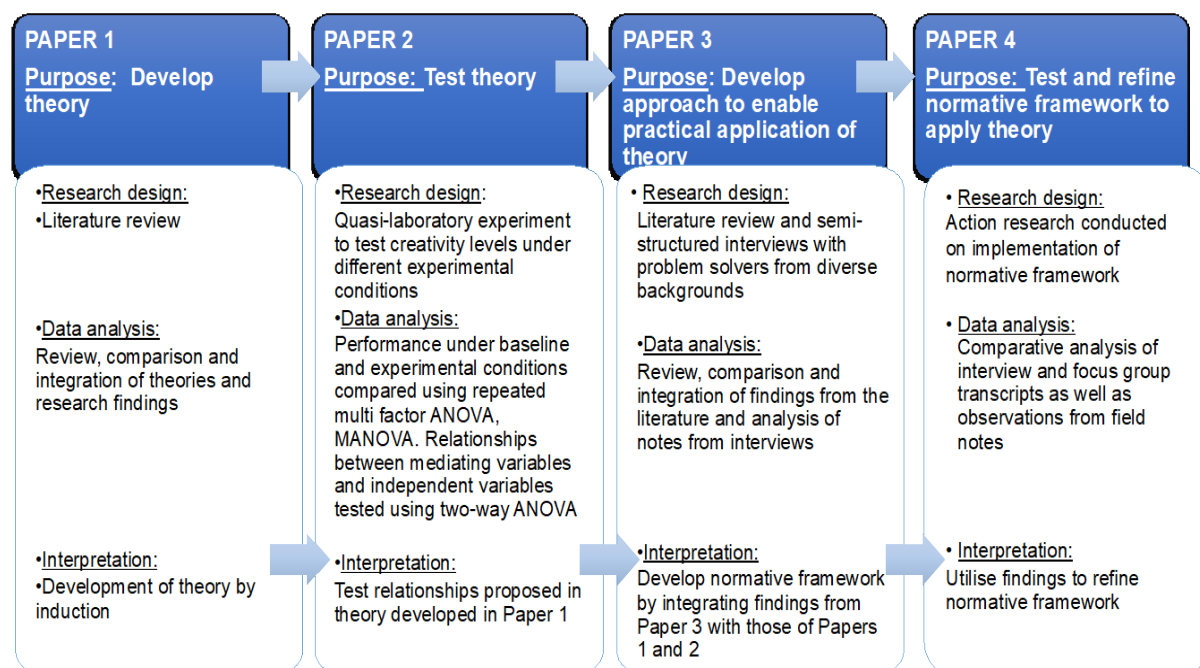
The thesis also seeks to provide a methodological contribution through the development of a normative framework to implement the theory.

3 DEVELOPMENT OF THIS THESIS IN FOUR PAPERS

This thesis was developed in four papers, for which the purpose and methodology of each is outlined in Figure 1 below.

Figure 1

Sequential mixed methods methodology employed



As illustrated in Figure 1, this thesis begins with the development of a novel theory on an approach to problem construction in order to enhance the effectiveness of the creative problem solving process. This theory is then tested in a quasi-laboratory experiment in which participants use alternative approaches to problem construction prior to generating creative solutions. Drawing on the theory and experimental findings, a normative framework is developed to enable practitioners to implement the theoretical approach, after which this framework is tested and refined in an action research study.

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3.1 Research context

3.1.1 *Samples drawn from different sectors*

The intention was to develop a theory and normative framework relevant to multiple sectors. In the research design therefore, samples were drawn from different sectors such that findings may be integrated to develop a more robust theory of, and normative framework for effective creative problem solving.

3.1.2 *Implications of conducting research in the South African context*

This research has been conducted in South Africa, which has a dual economy, as defined by the World Bank, and therefore has elements of both the developed and developing worlds (Anwana & Anwana, 2020).

It could be argued therefore, that this research is relevant to both contexts, in which the motivating forces for creativity differ markedly. A trend driving creativity in the developed world, for example, is the increase in wealth and leisure time, such that consumers are looking for new forms of entertainment (Sawyer & Henriksen, 2024). One of the driving forces behind innovation in South Africa, on the other hand, is the potential for job creation (Moses, Sithole, Blankley, Labadarios, Makelane, & Nkobole, 2012). A high proportion of the more than two million small businesses in South Africa has emerged due to unemployment (Anwana & Anwana, 2020).

Innovation and creativity often emerge in developing economies where institutional support is lacking and industry is forced to forge an entrepreneurial path rather than rely on established infrastructure. Having less sophisticated infrastructure also demands more from individuals, who need to draw on their entrepreneurial and problem-solving skills to a greater extent than those in more developed economies. These skills are essential in overcoming barriers and ensuring that innovations are implemented, especially when external support is lacking (Zanello, Fu, Mohnen, & Ventresca, 2016). The impact of innovation may also be greater in developing economies, as incremental changes may be more beneficial in less sophisticated contexts (Zanello et al., 2016).

Individuals and organisations who participated in the studies in this thesis operate in both the the developed and developing economies. From the small business owners interviewed to the multi-national organisation used as the case site for the experimental study, all have to negotiate the particular challenges in the South African economy while operating and competing in an international context. It is argued, therefore, that this thesis has equal relevance in the contexts of the developing and developed world.

INTRODUCTION

In a post-COVID world, recognition of the need for creativity in all economies was marked by the United Nations naming 2021 as the “International Year of the Creative Economy for Sustainable Development” (Sawyer & Henriksen, 2024). In the face of the increasingly complex challenges facing the global community, we are united in our growing need for creative solutions.

PAPER 1: THEORY DEVELOPMENT

4 CONTEXT AND RATIONALE FOR APPROACH ADOPTED IN PAPER 1

In Paper 1 of this thesis, a theory is developed to explain the relationship between specific approaches to creative problem solving, focusing specifically on the problem construction phase, and the creativity of solutions developed using these approaches. The intention of this theory is to inform the practice of creative problem solving in organisations. It has been argued that research should not only extend knowledge but, without compromising academic rigor, it should be leveraged in practical application (Van Maanen, Sørensen, & Mitchell, 2007; Van de Ven & Johnson, 2006; Pettigrew, 2001). In developing this theory, the aim is to not only contribute to academic knowledge but also to bridge the oft lamented gap between academia and professional practice.

A principle informing the development of the theory was therefore to identify underlying cause and effect relationships, such that where causes pertain to nebulous concepts that are difficult to manipulate, underlying causes which can be more easily shaped were sought, in order to bring about the higher order causes and effects. While a theory provides broad explanations of relationships between concepts that help us to explain phenomena, a model enables prediction and translates the implications of theories into real world contexts (Fried, 2020; Martens, 2020). The theory developed here is therefore subsequently encapsulated in a model. The aim of this model is to express the theory in a manner that incorporates specific approaches that can be purposefully controlled, rather than desired states or thinking styles, which are less easily induced or manipulated.

4.1 Models of creative problem solving: a process centred approach

Studies of creativity can be broadly broken down into four themes, namely those centred on the person, the process, the product and the environment (Isaksen, Puccio, Treffinger, 1993). Those focused on the person look at personal attributes, mindsets and skills; process centred studies investigate stages and strategies; studies of creative products analyse distinguishing features of creative outputs; and environment centred studies investigate environmental conditions that support or limit creativity. Leaders play a significant role in shaping the organisational climate for creativity. A meta-analysis of such factors has highlighted a number of culture-specific factors as having shown positive correlations with creativity, with the key factors being employees' positive perceptions of the organisational climate, positive interactions with other employees, intellectual stimulation, mission challenge, and a flexible culture that encourages risk taking (Mumford et al., 2020).

Given that in this thesis, the intended application of these research findings is to develop a practical approach that can be implemented by organisations to develop creative solutions to specific challenges, the focus in reviewing the literature has been on person centred and process centred studies. The reason for not including product centred studies is that the nature of creative output required varies across organisations and industries.

Environmental studies have not been included as environmental factors, which include the perceived organisational culture, leadership styles, reward structures, working conditions and industry dynamics (Isaksen et al., 1993), are challenging to manipulate, certainly in the short term, when the objective is to facilitate the development of a creative solution to a specific challenge.

Person centred approaches such as Amabile's Componential Model (Amabile, 1983), focus on the personal attributes that might be required in creative thinking. In an organisational context, employees with a wide range of personal attributes which may vary with regard to their suitability for creative thinking, may be required to generate creative solutions to particular problems. Given the inherent time constraints within which organisations operate, it may not be practical to implement the interventions that support development of the personal attributes conducive to creative thinking before engaging with the specific problem. It is suggested therefore, that applying a methodology with specific implementation guidelines would provide a more practical way of leveraging creativity amongst employees. However, person centred research offers insights into thinking styles and approaches which such a process centred approach should be designed to engender.

The creative problem solving process is described below in a process model which has evolved over time and which, research has suggested, has great potential for application in organisations (Puccio, Firestien, Coyle, & Masucci, 2006; Scott, Leritz, & Mumford, 2004; Torrance, 1972). In his assessment of the effectiveness of training in creative thinking, Torrance (1972) found that training based on creative problem solving and productive thinking proved most successful. Later research, such as that conducted by Puccio et al. (2006), has confirmed the value of the process, which has been shown to work well in an organisational context. These promising findings suggest it would be valuable to explore specific approaches to enhance the creative problem solving methodology, which is the purpose of this thesis.

4.1.1 The creative problem solving model and its iterations

Before proposing approaches to enhance the model, it is appropriate to provide an overview of prominent creative problem solving models in the literature and their evolution over time. In this thesis, when referring to these models, the abbreviation 'CPS' will be utilised, as this abbreviation is adopted in the literature.

PAPER 1

In the original creative problem solving model developed by Osborne (1963), the stages of creative problem solving were clearly described to provide insights into the sequential nature of the process. Subsequent modifications to this model by Parnes (1972) and Isaksen et al. (1994, 2011) led to the expansion of the original model into a six step process.

The six core steps are described as:

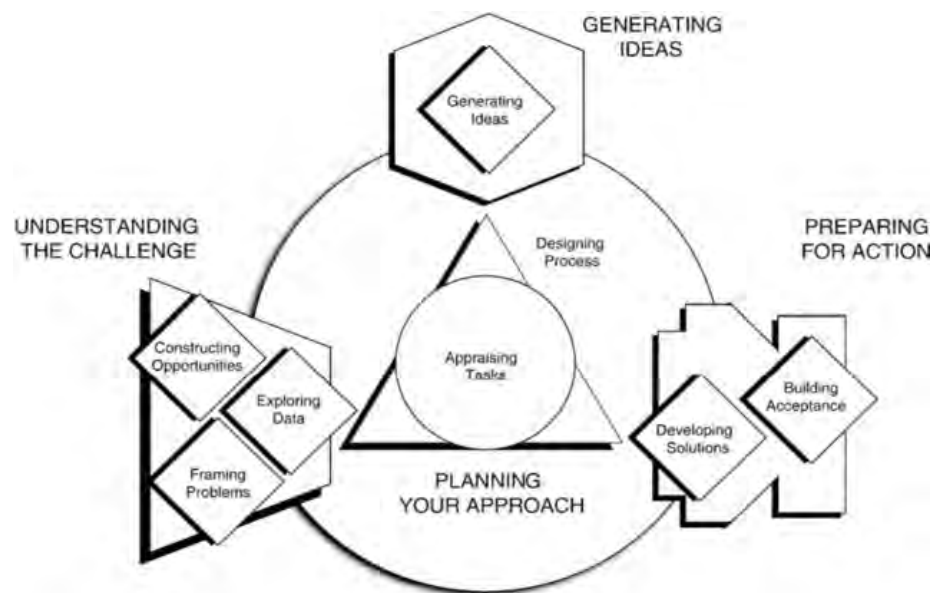
- 1) constructing opportunities or mess-finding—locating a problem for application of the problem solving process
- 2) exploring data or fact-finding—collecting, assessing, and reviewing all the available data pertaining to the problem
- 3) framing problems or problem-finding—listing all possible ways of defining the problem
- 4) generating ideas or idea-finding—generating ideas for solving the problem, including those that are wild or unusual
- 5) developing solutions or solution-finding—choosing and applying criteria for evaluating ideas to find the best solution, and
- 6) building acceptance or acceptance-finding—plan implementation by identifying responsible persons, a timeline of actions, and available resources.

In CPS version 6.1, these six steps were concatenated into three stages, described as understanding the problem, generating ideas and planning for action. (Isaksen et al., 2011). The update to this model includes the addition of what is termed a 'management component' entitled 'planning your approach', which comprises the two steps of appraising tasks and designing processes (Isaksen et al., 2011). This management component is used to plan implementation of the process while considering the organisational context, but the core three stages of CPS version 6.1 have been retained.

While there are minor differences in the various process models of creative thinking and creative problem solving, (Allen & Thomas, 2011; Basadur, Graen, & Green, 1982; Isaksen, Dorval, & Treffinger, 1994, 2011; Mumford & McIntosh, 2017; Osborne, 1963; Parnes & Noller, 1972; Puccio, Cabra, Fox, & Cahen, 2010) all of these models contain the three high level stages depicted in CPS version 6.1 depicted in Figure 2 below (Isaksen, Dorval, & Treffinger, 2000, 2004).

Figure 2

Creative problem solving model version 6.1



The terminology used may differ but the three stages of problem construction, idea generation and planning for action persist throughout. By way of example, Puccio et al. (2010) have used the terms ‘clarification’ (exploring the vision and formulating challenges), ‘transformation’ (exploring ideas and formulating solutions), and ‘implementation’ (exploring acceptance and formulating plans).

Another example of this is the creative thinking process model developed by Mumford and McIntosh (2017), in which these three stages also underly the eight steps described. The first three steps of problem definition, information gathering and concept/case selection fall into the first stage of problem construction, the second two steps of conceptual combination and idea generation constitute the second stage of generating ideas, and the third stage of planning for action is comprised of the last three steps of idea evaluation, implementation planning and adaptive execution.

A Sub-stages of the three stages

Using the terminology of the creative problem solving model version 6.1 depicted above, which remains the most recent iteration of the CPS model (Treffinger, Isaksen, & Stead-Dorval, 2023), the first stage of understanding the problem is comprised of the three sub-stages of constructing opportunities (or problem finding), exploring data (or information search) and framing problems.

The second stage of idea generation has no sub-stages but may incorporate the use of a variety of different ideation techniques, and the third stage of planning for action is comprised of the sub-stages of developing solutions and building acceptance.

This process has been applied across a wide variety of contexts to clarify and demystify creative problem solving, thereby empowering individuals in both their personal and professional contexts with insights into the process (Treffinger et al., 2023). In particular, the model has been used to good effect in training employees to apply these principles, with findings indicating that skills in creative thinking improved significantly (Puccio et al., 2020). On the back of these findings a graduate programme was subsequently developed at Buffalo State University to support teaching of and research into creative problem solving skills.

4.2 Use of a structured process rather than skills development

Much emphasis has been given to the development of knowledge of and skills in practicing idea generation techniques, probably owing in part to the still popularly held view that creative thinking can be equated with divergent thinking (Torrance, 1972). However, the importance of guarding against this simple equation has been repeatedly stressed (De Bono, 1996; Isaksen & Treffinger, 2004; Scott et al., 2004). Creative problem solving requires not only skills in divergent thinking, which is required in the idea generation stage, but also skills in convergent thinking which is necessary in the other two stages. Isaksen and Treffinger (2004) specifically emphasize how their work on refining the creative problem solving model over time, has included illustrating the roles of both divergent and convergent thinking at different stages in the process.

A question that remains open in the literature, is how individuals can be supported to develop not only skills in application of ideation techniques, but also the requisite skills in convergent thinking as well as the other two categories of skills described by Amabile (1983), namely changing habitual thinking to 'break set', or the ability to expend the required effort while maintaining focused and disciplined thinking when a problem appears intractable. (See discussion on cognitive persistence in Section 6.2).

Mumford and his co-authors, (Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991; Mumford, Peterson, & Childs, 1999) have also described a set of creative thinking skills or styles, defined according to the stages of creative problem solving. These eight 'processing operations' have been described as (a) problem construction or problem finding, (b) information gathering, (c) concept search and selection, (d) conceptual combination, (e) idea generation, (f) idea evaluation, (g) implementation planning, and (h) action monitoring.

Research has shown that training in creative thinking skills does indeed enhance creativity (Scott et al., 2004), but the impact of training on the development of these eight core processing operations varies according to the content of the training. In this study, the term 'problem identification' was used to describe problem construction. (See discussion in Section 4.3 below)

The effect size for training on problem identification ($r = .37$) was greater than the effect size for training on all other content, including idea generation ($r = .21$), implementation planning ($r = .19$), solution monitoring ($r = .17$) and conceptual combination ($r = .16$). With regression weights of $\beta = .48$ for problem identification, followed by $\beta = .18$ for idea generation and $\beta = .14$ for conceptual combination, it was clearly found that it was training in problem identification that contributed the most to the effectiveness of training.

A particularly interesting finding of this study was that when training emphasized the development of exploratory techniques, it was less effective and when it emphasized analytic techniques, training was more effective. An explanation proffered for this finding is that it is the inclusion of heuristics, checklists and strategies in training on analytic techniques that accounts for the relative success of this type of training (Scott et al., 2004).

When taken together, these findings that training is most effective when focusing on problem construction and the provision of structured tools and techniques, imply that providing individuals with a structured methodology for creative problem solving focused on problem construction could potentially have a significant impact on the effectiveness of their creative problem solving. It is suggested therefore, that if the aim is to support the creativity of employees, providing them with a structured process, with particular emphasis on problem construction, is likely to be more effective than training to enhance creative thinking skills.

Beyond the scope of problem construction too, following a structured process has been found to increase the probability of generating creative solutions (Boyd & Goldenberg, 2013; Rietzschel et al, 2014). In fact, even externally imposed structure is likely to enhance creativity of outputs (Sagiv, Arieli, Goldenberg, & Goldschmidt, 2010).

Against this background, it is important to note that when the structure of a process produces habitual practices, this does not support creativity (Stokes, 2007). This is especially true when the potential for variability is introduced, such as when routinisation is designed to limit the range of behaviours (Ford & Gioia, 2000). Structured processes should therefore be purposefully designed to enhance, rather than suppress variability of responses.

4.3 Rationale for focusing on problem construction

Theorists view all stages of the creative problem solving process as fundamental in generating novel, useful solutions (Isaksen et al., 2011) and while there are opportunities to explore approaches to optimize the effectiveness of the entire process, the stage which constitutes the focus of this thesis is the first stage of problem construction.

While there are different opinions as to the veracity of the quote attributed to him, Einstein is purported to have said that if he had one hour to save the world, he would spend 55 minutes defining the problem and 5 minutes solving it. Because problem construction provides the context for the application of other processes in the creative problem solving effort, many argue that the way the problem is constructed will have a marked impact on creative production and solution generation (Getzels, 1979; Mumford et al., 1991; Runco & Okuda, 1988).

It is suggested therefore, that exploring alternative approaches to problem construction could yield potentially valuable insights that could be utilised to provide evidence based guidelines to support the optimal implementation of creative problem solving in organisations.

Research has demonstrated that problem construction explains different levels of creativity above and beyond differences in intelligence and divergent thinking skills (Reiter-Palmon & Robinson, 2009; Runco & Okuda, 1988; Smilansky, 1984;). In fact, there is a substantial body of evidence that defining and describing the problem is the most important stage in the creative process (Getzels, 1975; Getzels & Csikszentmihalyi, 1977; Getzels & Smilansky, 1983). In a meta-analysis, Ma (2009) found that of all cognitive processes, problem construction and identification had the strongest relationship with the creativity of ideas generated. Research conducted by Csikszentmihalyi and Getzels (1977), Getzels (1975), Getzels and Smilansky (1983), Okuda, Runco and Berger (1991) and Reiter-Palmon, Mumford, O'Connor Boes and Runco (1997) indicated that skills in problem construction were the best single predictor of creativity in realistic contexts.

Reiter-Palmon, Mumford and Threlfall (1998) suggest that problem construction ability contributes to successful problem solving in two ways. Firstly, it has a direct effect on solution quality and solution originality, and secondly it has an indirect effect on problem solving through its effect on solution fit to the personality type. Individuals with high problem construction ability are able to construct an ambiguous or ill-defined problem in a way that they can relate to or understand. They are also able to construct the problem in a way that matches their personality type. This, in turn, allows them to provide a high quality, more original solution because they are now dealing with a more familiar problem or drawing on their own expertise.

Runco and Nemiro (1994) present the interesting point that taking time to define a problem may also enhance intrinsic motivation, as if the person is deeply involved in constructing the problem, it is most likely that it will be one that will hold their interest.

Csikszentmihalyi and Getzels (1971) initiated research in this area by investigating the problem construction skills of 31 art students and found that these skills predicted the creativity of a still-life painting.

Moreover, problem construction skills predicted the students' long term success as artists, based on measurements taken seven years later.

Reiter-Palmon and Robinson (2009) claim that it was only in the 1990s that there was a substantial increase in the empirical study of problem construction, but these studies have consistently shown that problem construction does indeed have notable effects on creativity. In particular, it has been found that problem construction (a) is related to more original and creative works of art and long-term success as an artist, as described above, (Getzels & Csikszentmihalyi, 1977), (b) is related to problem-solving ability (Smilansky, 1984), (c) is the best single predictor of real-world creative activities (Okuda et al., 1991), and (d) results in higher quality and more original solutions (Reiter-Palmon et al., 1998; Redmond, Mumford, & Teach, 1993; Reiter-Palmon, Mumford, Boes, & Runco, 1997).

Reiter-Palmon et al. (1997) also assert that more active involvement in problem construction results in the problem being looked at in more ways. Their research indicated that an important function of problem construction is to provide a coherent and workable problem representation. (Reiter-Palmon et al., 1997). It was interesting, however, that their attempts to increase active processing were not successful, which they hypothesise was due to the problems selected for the study – namely, problems with which research participants were already familiar. These problems were therefore likely to have been subjected to some level of active processing already. In contrast, the activation of active processing of the problem construction in a similar study by Redmond et al. (1993) did have successful results, which Reiter-Palmon et al. (1997) hypothesise was due to the unfamiliar nature of the problem. It could be deduced from these findings that when the problem solver is familiar with the problem, they may be resistant to considering it from alternative perspectives. This is associated with the risk of fixation associated with expertise discussed in Section 6.5.1 below.

Basadur, Graen and Greene (1982) who looked at both whether and how training works to improve creativity or creative problem solving, hypothesise that "Problem finding for many people in our culture appears to be a somewhat unfamiliar chore, especially for people who tend to operate more in problem-solving or solution-implementation modes." (Basadur, Graen, & Greene, 1982, p.67).

This view is echoed by Basadur and Basadur (2011) in the assertion that while most people understand problem solving and implementing, fewer understand problem conceptualization, and even fewer, problem generation, which is the first of the three steps in the stage of problem construction. This may well provide some insight into why training in problem construction is so impactful: firstly, problem construction itself plays an important role, and secondly, skills in problem construction may not be well developed due to the prevailing focus on generating solutions.

As discussed in Section 4.2, in this thesis a process centred rather than a person centred approach is adopted. Therefore, as an alternative to developing skills in problem construction, it is suggested that a process for problem construction could facilitate more effective problem construction. Using the framework of Isaksen, Dorval and Treffinger (2000, 2004) described above, the proposed process will focus on two of the sub-stages of problem construction, namely exploring data (or information search) and framing problems. It should be noted, however, that while stages in the creative problem solving process are described sequentially, it is understood that the stages do not function as discrete steps, but that in the complexity of a real world context, a problem solving process needs to be applied in a flexible and iterative manner (Checkland, 2000; Hindle, 2012; Runco & Nemiro, 1994). In the experiment to test the theory proposed in this thesis, problem framing precedes information search, although in practice this will typically be an iterative process.

4.3.1 Sub-stages of problem construction

Basadur and Basadur (2011) see problem construction as comprising two key components, the first being defining of the problem, which they call problem generation (initiation and discovery) and the second stage, which they call problem conceptualization (problem identification or construction). Barsalou (1983) and Holyoak (1984) break problem representation down further into four components: the goals and outcomes associated with the problem-solving effort, constraints or restrictions placed on solutions, key information needed to solve the problem, and procedures used for problem solving. Mumford, Reiter-Palmon and Redmond (1994) define problem construction as the process whereby individuals structure an ill-defined problem and identify the goals and objectives of the problem-solving effort.

Reiter-Palmon and Robinson (2009) note that while different terms have been used to describe this first stage, including problem definition, problem identification, problem recognition, and problem construction, they all refer to the process in which a problem is identified by the problem solver, an ill-defined problem is structured, and the parameters of that problem are defined. Furthermore, the process models described in Section 4.1.1 above also typically include the same sub-stages of problem construction.

4.4 Rationale for focusing on problem framing and information search

Although, as discussed in Section 4.3.1 above, the terminology used might vary, and while different process models may include other sub-stages such as problem identification (Isaksen et al., 2011) or concept selection (Hunter, Bedell & Mumford, 2006) the sub-stages of problem framing and information search are consistently incorporated as sub-stages in problem construction.

It is these two sub-stages which are the focal points of the theory developed in this thesis.

For the purpose of this thesis, the definition of 'problem framing' employed is that found in version 6.1 of the CPS model in which problem framing is described as "...seeking a specific or targeted question (problem statement) on which to focus subsequent efforts." (Isaksen & Treffinger, 2004, p.19). This involves the process of defining the scope of the problem to be solved.

The term 'information search' is self-evident, and refers to the gathering of data that informs the understanding of and perspective on the problem and the subsequent stage of idea generation.

The information search and problem framing therefore provide the foundation for the generation of creative solutions, as together these sub-stages shape and define the problem to be addressed.

In the model developed in this thesis, the first sub-stage of problem construction which involves the initial identification the problem, will not be addressed. This sub-stage, also named 'mess finding' by Parnes and Noller (1972), is the natural first step in identifying opportunities for innovation, but this sub-stage is more likely to be influenced by serendipity or circumstance or result from a broad scanning of the environment than being amenable to direct manipulation. As such, it is suggested that it is not appropriate to use a structured methodology to find good problems, as it is unlikely that a consistent approach will be effective across a wide range of contexts.

4.4.1 The role of problem framing

It is argued here that there is a need to distinguish problem framing from problem finding and problem construction. Reiter-Palmon and Illies (2004) argue that different terms used in the various versions of the CPS methodology all really describe similar concepts, but it is worth noting the potential pitfalls of the changes in the use of terminology over time. Besides the more innocuous problem of creating some level of confusion, changes in meanings of terms pose the risk that certain cognitive processes can be overlooked and not given the attention that is warranted when they are subsumed in other terms.

When referring to the entire stage of problem construction, for example, it can be inferred from a deeper reading of the literature that it is in fact the step of problem framing that is being referenced (Reiter-Palmon & Illies, 2004). There are also instances where the term 'problem finding' is used to describe the entire stage of problem construction, but again it is clear that the cognitive processes being referenced are those pertaining to problem framing specifically (Basadur, Graen, & Green, 1982; Redmond et al., 1993).

This can be understood in the context of the latest version of the CPS model at the time, version 3.0, in which problem framing was described as problem finding and the initial step of problem finding is referred to as 'mess finding' (Isaksen & Treffinger, 2004).

However, it is also possible that the reason for problem framing predominating in the conception of problem construction is that the initial identification of the problem is the step prior to active manipulation of the problem, and the role of information search in problem construction is not prominent in the literature. It is suggested then, that the term problem framing is more cognitively available for application as a synecdoche, as its role in reconceptualising and redefining the problem statement is readily grasped and well researched.

The significance of the role of problem framing, taken together with the longstanding disparate opinions on whether narrow or broad framing is preferable and how problem framing should best be conducted (see Section 6.7), indicates a need for further research if a normative framework is to be proposed to facilitate effective creative problem solving. This is especially relevant when considering optimal approaches to the information search, as there is clearly an interdependent and reciprocal relationship between the scope of the problem frame and the scope of the information search.

4.4.2 The role of the information search

Information search is an explicit step within the problem construction phase of the CPS model, and plays a pivotal role in creative problem solving. It is well accepted that drawing on more information will support greater creativity (Steele, McIntosh, & Higgs, 2017) and Mayer (2006, p.154) asserts that "...creative problem solving favours the prepared mind.". It is surprising therefore, that there is a dearth of research into the role of information search in the generation of creative ideas or solutions (Harms, Reiter-Palmon, & Derrick, 2020). These authors in fact, go so far as to say that "...no research has separated and measured information search from earlier processes to determine the nature of the role it plays in the creative problem solving process". (Harms et al., 2018, p.1)

In the course of the literature search conducted for this thesis however, a few studies relating directly or indirectly to the information search have come to light.

One such study was conducted by Mumford, Baughman, Supinski and Maher (1996) in which they explored the role of information processing. Here it was found that reviewing information about the subject of the problem did improve creative problem solving. The way in which the information search was conducted was also relevant, and creative problem solving was positively associated with time spent, focus on relevant facts and identification of anomalies.

An important finding from the Illies and Reiter-Palmon (2004) study however, is that time spent on information search is less important than the active processing of this information. In fact, beyond a certain point, time spent on information search is not likely to be productive (Steele et al., 2017). This raises the question of whether there are optimal search strategies that can be employed, not only to utilise the time spent to maximum effect, but also to develop the rich, granular and fluid mental models that provide the fertile soil required to facilitate conceptual combination and the generation of creative solutions to complex problems (See Section 6.5.3).

A review of the literature supports the assertion of Harms et al. (2018), that there is not only a lack of research into the role of information search in supporting creative thinking, but a particular gap in literature that addresses alternative approaches towards information search. One of the objectives of this thesis is to propose and test an approach to information search designed to optimise its role in supporting creative thinking and problem solving.

4.5 Rationale for focusing on individual rather than team

While it is well accepted that organizational creativity needs to be studied and addressed at different levels, namely the individual, the team and the organisation, and should be viewed from a systemic perspective (Puccio & Cabra, 2010) and as an emergent phenomenon (Sawyer, 2010), the focus of this thesis is to facilitate and support creativity at the level of the individual. The intent is to develop a theory and related normative framework that could be applied at both the individual and team level, but the primary focus of the research is at the individual level.

The first reason for this is that focusing on the individual allows for relatively targeted facilitation of creative thought processes, whereas an approach designed to enhance creative problem solving at the team level must address the many, varied and systemically interacting variables that impact on team performance. It is acknowledged that the nature of social networks, including the strength of connections and the individual's position in this network are likely to affect levels of creativity (Perry-Smith & Shalley, 2003), however, as the focus of this study is to develop a theory that can inform the development of a normative framework for problem construction, the management of relationships in organisations is beyond the scope of this study.

More significantly, the second reason for focusing on the individual is the prevalence of findings in the literature that individuals are shown to be consistently more effective at generating creative solutions than teams (Boh, Evaristo, & Ouderkirk, 2014; Dennis & Valacich, 1994; Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991; Mumford, 2000; Taylor & Greve, 2006; Reiter-Palmon, Herman, & Yammarino, 2008).

One unequivocal quote encapsulates the findings: “When working alone, originality is most likely; when working in a dyad with one other individual, being original is slightly less likely because there is a small amount of the risk defined above; and every time the group increases, the risk increases, and the probability of being original decreases.” (Runco, 2010, p.416.).

A related finding by Taylor & Greve (2006) indicated that individuals are more effective than teams at combining knowledge from diverse fields to generate more creative solutions. In a very definitive assertion on this matter, Thompson & Brajkovich (2003) question why the perception that groups are more creative than individuals persists in the face of overwhelming evidence to the contrary, based on research on brainstorming that spans approximately forty years. They point to the consistent finding that individuals working independently produce far more creative results than brainstorming groups. Furthermore, they highlight the finding that “...virtually all of the empirical investigations of group brainstorming are strongly (not just mildly) negative about its effectiveness compared to solitary brainstorming.” (Thompson & Brajkovich, 2003, p.100).

4.6 Methodology employed in theory development

While there is no single definition of a theory it may be broadly described as an explanation and prediction of the relationships between independent and dependent variables (Colquitt & Zapata-Phelan, 2007; Fried, 2020). Importantly, a theory should also be generative, such that it can spawn new hypotheses over time (Martens, 2020).

The approach to theory building used in this paper can be described as philosophical conceptualisation, as the theory is developed by reviewing and analysing the literature to identify higher level concepts, deconstructing certain concepts into their underlying constructs, integrating propositions regarding relationships and proposing new relationships between concepts (Meredith, 1993). As the aim of developing this theory was to explain how problem construction can be optimally structured to generate more creative solutions, building of this theory concentrated on review of the literature specifically related to the sub-stages of information search and problem framing. The theory was subsequently tested experimentally and then developed into a normative framework.

The process of theory building has been described by Rivard (2021) as a series of iterations, each with a specific goal. According to this model, each iteration of the theory building process contains the activities of reading, writing and reflecting and may take place concurrently, but each iteration differs with regard to the key goal or outcome sought. This iterative model of theory building presented in this paper has been used to describe the stages of the deductive theory building process adopted in the development of the concentrated curiosity theory in Table 1 below.

Table 1

Requirements in stages of theory development (Rivard, 2021) and their application in this study

Iteration	Application to building the concentrated curiosity theory
Iteration 1: Activities: Read, reflect, write Outcome sought: Erudition In this stage, a broad and deep review of the literature is conducted to establish knowledge of the domain, that in turn informs how the researcher approaches the literature. Works are also categorised in emerging themes	The literature on creativity, innovation and creative problem solving was reviewed to obtain an understanding of developments in the field since its inception in the 1940's, and particularly how employees are supported to apply creative problem solving in organisations. Works were classified according to their stage in the evolution of model of creative problem solving, their focus on different stages in the creative problem solving process, and factors supporting the effectiveness of creative problem solving. The stage of problem construction was identified as a key lever of the creative of solutions.
Iteration 2: Activities: Read, reflect, write Outcome sought: Motivation With the reading becoming more critical, the goal of reading is to identify gaps in the literature. More specifically, gaps are sought in relation to competing or contradictory evidence or explanations, areas where research is lacking and opportunities to apply theories or perspectives.	The lack of literature on the sub-stage of the information search was identified as an important gap to be addressed within the sub-stage of problem construction. Thereafter, conflicting findings and opinions on approaches to problem framing were noted. A key gap was addressed in the practical application of theory, as existing process models described the process but provided no evidence based guidelines as to optimal approaches to implement the process.
Iteration 3: Activities: Read, write, reflect Outcome sought: Definition This iteration of theory building is primarily concerned with defining the scope of the phenomenon and distinguishing and delineating concepts within the phenomenon that are to be addressed in the theory. The type of theory being developed is also clarified.	The end states of the conceptualisation of the problem and thinking styles elicited were identified as the key constructs to be addressed. In this stage, these end states were identified as being cognitive flexibility, cognitive persistence, intrinsic motivation, doubt, curiosity and domain expertise. These concepts, their constituent constructs and approaches to defining them were explored. and the relationships between them were explored with a view to developing theory a theory of optimal problem construction that would have practical implications.

Iteration	Application to building the concentrated curiosity theory
Iteration 4: Activities: Research, read, reflect, write Outcome sought: Imagination In this stage, the objective is to spark imagination regarding potential new insights or contributions, specifically related to generating ideas about relationships between concepts identified in the previous iteration.	An important source of inspiration for the development of the concentrated curiosity theory was the dual pathway model (De Dreu, Baas, & Nijstad, 2008; Nijstad, De Dreu, Rietzschel, & Baas, 2010), that posed an intriguing quandary, namely that the problem solver could adopt either a persistence or flexibility pathway but that these two pathways were negatively related. This inspired the idea that this theory could address the challenge of how to stimulate both cognitive flexibility and cognitive persistence. The intriguing question that emerged was whether there would be an approach to problem construction that could stimulate both pathways.
Iteration 5: Activities: Respite, read, reflect, write Outcome sought: Explanation and presentation Intricacies of relationships between concepts need to be explored and explained, and propositions are formulated regarding these relationships. The process of presenting the theory, often in visual form as a model, may assist in clarifying relationships – not only for the reader but for the researcher.	Development of the visual model that depicted and encapsulated elements and relationships within the concentrated curiosity theory was conducted in parallel with the theory development as it highlighted the need for clarity and specificity. Relationships that were originally seen as primary, such as the role of intrinsic motivation, were reformulated as subsidiary, as the argument emerged that the purpose of intrinsic motivation was cognitive persistence, such that it was cognitive persistence fed into the dependent variable of the creativity of solutions whereas intrinsic motivation was positioned as a means to supporting cognitive persistence in the theory.
Iteration 6: Activities: Review, renounce, revise, read, reflect, write Outcome sought: Contribution This iteration requires the review of conceptualisations of constructs, which may be challenging as this may lead the researcher to renounce certain elements that can threaten the stability of the theory that is being built.	The previous iteration, in which the visual model of the theory was developed, served to expose areas that needed to be reconceptualised. For example, the concept of domain expertise was revised to complexity of mental models, as this was discovered to be the ultimate goal of domain expertise as pertain to the relationships in the theory. Domain expertise now became an input – a means to an end of developing a complex, fluid mental model of the problem.

Prior to the development of the theory, the philosophical underpinnings of the theory are discussed, providing a rationale for the selected avenues of investigation and the approach adopted in constructing the model that expresses the predicted effects of the theory. Thereafter, in describing the model, findings regarding the key concepts and casual relationships between them are described and discussed.

5 PRINCIPLES INFORMING THE CONCENTRATED CURIOSITY THEORY AND MODEL

The concentrated curiosity theory rests on two philosophical tenets. The first tenet is that while creativity may be a natural human proclivity, it competes with the allure of a quicker, easier and more efficient way of thinking. This implies that sitting back and waiting for inspiration from one's muse is not an approach that can be relied upon to deliver creative solutions to challenging problems, but rather that determination, focus and persistence offer a more dependable route to effective creative problem solving. The second, related tenet, is that creativity flourishes when the paradox of both constraints and freedom is embraced. This implies that creativity requires both constraints and freedom, rather than one at the expense of the other. These principles are expanded upon below.

5.1 Hard work trumps the muse

While there has certainly been progress in this regard, the myth of the muse still lurks around the concept of creativity, as perceptions still prevail that creativity is an elusive, ethereal concept and belongs primarily in the domain of the arts (Benedek et al., 2021) It is suggested that the persistence of such myths is not wholly innocuous (Sternberg, 1999).

Although the increase in scientific studies of creativity indicates a general acceptance that the subject should be seen as a science, rather than a mystical property with which rare individuals are blessed, traces of this myth can still be seen in the 'total freedom' perspective described by Goldenberg, Mazursky and Solomon (1999), which holds that if all constraints are removed, and the individual is allowed to let their thoughts roam free, their resident muse will invariably liberate their inherent creativity. Interestingly, this decidedly unscientific approach appears to predominate in the many organisation which attempt to encourage creativity by asking employees to simply 'think out of the box' or break with tradition to come up with a creative idea (Goldenberg et al., 1999).

This approach, which is based on the assumption that simply removing the walls of the box, or constraints, will automatically awaken dormant creative solutions, reflects the underlying assumption that our inherent creativity is simply waiting to be unleashed, and doesn't need any shaping or management.

It is suggested that fragments of this mythical view of creativity are also responsible for the prevalent view that deep analysis and hard work are antithetical to creativity and that the optimal mindset for creativity is a relaxed, unfocused state (Friedman & Forster, 2005; Baas, De Dreu, & Nijstad, 2011). This view is reflected in the popularly held assumption that there is a schism between the so-called left brain, analytical mode of thought and right brain, creative thinking, despite evidence that no such schism exists (Benedek et al., 2021).

The theory developed in this thesis is based on the contrary argument that in fact hard work, focus and persistence are key to creative problem solving. This approach is exemplified in the response Newton reportedly provided to the question of how he had discovered the law of universal gravitation: “By thinking on it continually” (Westfall, 1980, p.110)

Studies demonstrate quite comprehensively that creative achievements in the arts and sciences are built on a high level of domain expertise that comes from effortful practice over time (Ericsson, 1999; Weisberg, 2006). In arguing against the tabula rasa as an invitation to the muse, Weisberg asserts that “The critical difference between creative and non-creative thinkers might be in the time the former spend in their domain-specific development, which results in the acquisition of the rich database that will ultimately serve as the foundation for their innovations” (Weisberg, 2006, p.40). Creative problem solving is not easy and, almost by definition, requires pushing beyond the readily available answers, which necessitates dedication and tenacity (Csikszentmihalyi, 1988, Ward, 1994). This is well illustrated in the simple quote: “Perhaps the single most reliable finding in our studies is that creative work takes a long time” (Gruber & Davis, 1988, p. 264, as cited in Baer, 2015).

While it is conceded that creative solutions can also be generated when adopting a broad perspective and a relaxed, unfocused state of mind, the argument that informs the theory developed in this thesis is that in an organizational context, where time and resources are limited, this approach is likely to generate a lower proportion of truly creative solutions in the time allocated. An intention behind the development of the theory in this thesis is to optimise the proportion of original and practical solutions generated in a given time period.

5.2 Constraints versus freedom: the case for harnessing the power of the paradox

Over time, opinions and research findings regarding the role of constraints in creativity have varied (Acar, Tarakci, & Van Knippenberg, 2019; George, 2007; Shalley, Zhou, & Oldham, 2004; Tromp, 2024; Zhou & Shalley, 2003).

In this, the second principle informing the theory, it is argued that benefits of the ‘total freedom’ approach described above would be enhanced through an approach that allows for the parallel and thoughtful application of constraints. While the very word ‘constraint’ may have negative connotations, which could be seen as antithetical to creativity, a nuanced approach stands to harness the benefits of constraints (Tromp & Sternberg, 2022) .

The arguments for freedom versus constraints are outlined below. Findings regarding the effects of different types of constraints and different ways of applying constraints are also explored.

5.2.1 Arguments for freedom

The widely held perspective that freedom is an essential ingredient in creativity, is based on the assumption that in order to break away from traditional modes of thinking, individuals and groups need to operate in an unbounded context, with little to no externally imposed structure (Amabile, 1988, 1996a; Sagiv et al., 2010; Shalley et al., 2004).

Any structure imposed on the creative problem solving process could be seen as a constraint, according to the definition of constraint provided by Rosso (2014, p.553) as “being restricted, limited, or confined within prescribed bounds”. Those who believe that working in an unbounded context is an essential ingredient in creativity also argue that constraints lead people to revert to familiar and superficial thinking (Rosso, 2014; Andrews & Smith, 1996). While the evolution of this dominant emphasis on the role of unfettered exploration in enabling creativity is beyond the scope of this thesis, it could be argued that the seeds of this perspective were sown by Torrance, one of the original fathers of creativity research, who emphasized divergent rather than convergent thinking, and in fact equated creativity with divergent thinking (Torrance, 1972).

The work of Amabile, the most cited creativity researcher according to Castillo-Vergara, Alvarez-Marin and Placencio-Hidalgo (2018), has subsequently facilitated the proliferation of this view that creativity flourishes in an unconstrained environment (Amabile, 1988), as much of the literature on this topic has employed Amabile’s (1988, 1996a) perspective on intrinsic motivation to argue that constraints have detrimental effects on creativity because they inhibit creators’ intrinsic motivation.

The premise that intrinsic motivation is key to creativity and that constraints inhibit intrinsic motivation, has been highly influential in theories about the impact of constraints on creativity.

It is argued here that it is this view which informs the dominant organisational approach to facilitating creative thinking, which is to encourage freedom of thought to elicit 'crazy' thinking in order to generate as many wild ideas as possible (De Bono, 1992; Goldenberg et al., 1999). Therefore while creativity is so highly valued in organisations, practical approaches adopted to instigate and enable creative problem solving are typically limited to encouragement, brainstorming – with or without the application of brainstorming rules - and creating a physical environment evocative of a nursery school. This is exemplified by the widespread practice of attempting to recreate a childlike mindset amongst employees by employing tools such as crayons and primary colours to invoke the release of inhibitions associated with childhood creativity (Harford, 2016). Organisations' assumptions that greater flexibility, freedom and minimal boundaries are pre-requisites for creativity is illustrated by Google's well publicised approach to encouraging individual expression in a physical environment that resembles a playground (Caniëls & Rietzschel, 2015).

5.2.2 *Arguments for constraints*

An opposing view to that described above, namely that constraints play a valuable role in facilitating creativity, is also well supported in the literature (Baer & Oldham, 2006; Gilson, Mathieu, Shalley, & Ruddy, 2005; Sutton & Hargadon, 1996; Stokes, 2007). Mumford, Reiter-Palmon and Redmond (1994) argue that creativity is not an unbounded process, as it draws on existing knowledge and processing skills, and that consequently there is value in exploring the nature of these constraints and how they operate. It can also be argued that when problem solving in an organisation, one will inevitably have to contend with a wide range of constraints, of which time and budgetary constraints are perhaps the most obvious but by no means the only parameters within which the problem must be solved.

In the study conducted by Scott et al. (2004) discussed in Section 4.2, in addition to demonstrating the relative impact of problem construction in the development of creative thinking skills, findings also suggest that constraints can facilitate creativity, as successful training courses devote less attention to techniques related to unconstrained exploration. Correlations and regression weights indicated that training courses stressing techniques such as critical thinking ($r = .22$, $\beta = .26$), convergent thinking ($r = .17$, $\beta = .12$), and constraint identification ($r = .15$, $\beta = .07$) produced the largest positive relations with effect size.

Sagiv et al. (2010) also argue for the positive impact of an imposed structure on creativity. More specifically, they claim that limiting the number of possibilities in a way that channels individuals to focus on the core elements of the problem, enhances creativity. They conclude that their findings indicate the usefulness of constraining the task, especially for individuals who prefer structure.

They go on to state that, consistent with previous research (e.g., Finke, Ward & Smith, 1992; Goldenberg & Mazursky, 1999), externally imposed structure increases creativity for all individuals, but that their research is the first to show that this beneficial effect is stronger for individuals who think systematically.

A Effects of different types of constraints

While research has been conducted to focus on the specific impact of different types of constraints, this is far from exhaustive. The relationship between time pressure and creativity is complex, and while some have asserted that there is a simple inverse correlation between time pressure and creativity (Andrews & Smith, 2006) other studies have not found such a simple relationship.

Baer and Oldham (2006) found a curvilinear relationship between time pressure and individual creativity, where moderate levels of time pressure had positive effects on creativity, only under conditions where employees had high levels of support for creativity and scored high on the dimension of openness to experience. Byron, Khazanchi and Nazarian (2010) also found a curvilinear relationship between time pressure and stress, but provided some useful pointers in interpreting the findings of their meta-analysis, namely that it is important to look at the individual's evaluation of the control they might have over the stressor, rather than the levels of the stressor itself. They found a significant relationship between perceptions of control and creativity, such that lower perceived control decreased creative performance levels and creative performance improved when perceived control was higher. It appears, therefore, that it is the evaluation of stress and control rather than the time limitation itself that is responsible for the curvilinear relationship between time pressure and creativity.

Additional provisos in interpreting the relationship between time pressure and creativity are provided by Hennessey and Amabile (2010) who concluded that while time pressure generally has a negative impact on creativity, time pressure can enhance creativity if creators are protected from distractions and feel as if they are motivated to achieve a particular goal. They concede, however, that such occasions are rare.

Mixed findings have been found with constraints regarding material resources. Amabile (1988, 1996a) and Amabile and Grysiewicz (1987) have suggested that creators need to feel comfortable and provided with sufficient material resources to allow for optimal creativity. On the other hand, Csikszentmihalyi (1997) suggests that resources can make people too comfortable, having a 'deadening' effect on creativity.

Researchers have also investigated the impact of constraints of standardised routines and processes on creativity.

While some studies have found that standardisation and formalisation hurt creative efforts (e.g., Mumford, Baughman, Maher, Costanza, & Supinski, 1997; Soriano de Alencar & Bruno- Faria, 1997), more recent research on group-level creativity suggests that standardised processes and routines, such as institutionalized problem solving or brainstorming methods that incorporate the imposition of rules, can positively impact team creativity, if under appropriate environmental conditions (Sutton & Hargadon, 1996; Gilson et al., 2005). For example, Gilson et al. (2005) found that teams with standardised routines and practices in place, in addition to being empowered by their organisation to be creative, were more creative than teams who were empowered to be creative but lacked standardisation.

This finding is consistent with past research demonstrating that clearly specified structures, rules, and boundaries can help promote group creativity if the organisation demonstrates clear support for creativity and if members of the group are familiar with and committed to those rules and structures (Sutton & Hargadon, 1996).

In their research with the design firm IDEO, Sutton and Hargadon (1996), also found that the creativity of brainstorming groups in a product development context was enabled by the presence of explicit, visible, and well-enforced rules for brainstorming such as “defer judgment,” “build on the ideas of others,” and “encourage wild ideas.” In fact, creative teams have even been shown to actively place constraints on themselves as a way of structuring or bounding their work in ways that enhance their creativity (Sutton & Hargadon, 1996; Stokes, 2007).

B Effects of constraints at different stages in the creative process

The question also arises as to whether imposing constraints at all stages in the creative problem solving process will play a similarly positive role, and there seems to have been a dearth of research exploring this question (Rosso, 2014).

It has been argued that constraints should not be imposed in a situation where creativity is desired until actual idea or solution generation has begun, that is, after information search and problem framing (Finke et al., 1992). These authors claim that factors constraining category formation will also constrain imagination, which suggests that problem construction should be open ended or unconstrained.

Other theorists have supported the diametrically opposing view that constraints of standardised routines and processes are particularly beneficial to team creativity at the early stages of the creative process because, by providing common approaches and procedures and clarifying expectations upfront, individuals can free up cognitive resources that would otherwise be spent on negotiating the rules of engagement rather than on creative thinking itself (DeRue & Rosso, 2009).

Another argument that supports applying constraints in the early stages of the creative process is that there will always be environmental or situational constraints such as those pertaining to the desired outcome and time constraints, and that these need to be defined and accepted upfront to inform and direct the creative problem solving process (Reiter-Palmon & Illies, 2004). In an organisational context, the reality is that there will be a number of goals, many of which will be in opposition to each other. Creative problem solving in the organisational context therefore implies inherent constraints to problem construction which will generally need to be framed to accommodate these conflicting goals. (Butler & Scherer, 1997; Stokes, 1999). As Reiter-Palmon and Illies (2004) suggest, the resultant additional effort and attention required in problem construction will lead to more creative solutions. In support of this argument, Mumford et al. (1996) found that those participants who applied restrictions in problem construction generated more creative solutions.

C Effects of perceptions of constraints

The way in which constraints are viewed appears to be influential, with a more positive perception of constraints being associated with a higher level of creativity under such conditions (Rosso, 2014). This may well be related to the finding that self-imposed constraints are also found to be more effective than externally imposed constraints (Herrmann, Goldschmidt, & Miron-Spektor, 2018).

5.2.3 Flexibility versus persistence: the two alternative pathways of freedom versus constraints

A model that attempts to incorporate the conflicting findings described above, is the dual pathway model (De Dreu, Baas, & Nijstad, 2008; Nijstad, De Dreu, Rietzschel, & Baas, 2010), in which two alternative, though negatively related approaches are proposed as being equally valuable in enabling creativity.

The first path is the persistence pathway, which employs executive control in sustaining and focussing attention and the exertion of cognitive effort. This thinking style is therefore characterised by the application of constraints to thinking, in order to maintain disciplined focus within a specified scope.

The second path is the flexibility pathway, which involves a fluidity in thinking that enables the adoption of different approaches or alternative perspectives on the problem. This path therefore involves unconstrained thinking in which attention and perspectives are free to shift, with the attendant freedom to consider alternative approaches and ideas in the context of an unbounded scope. While both are accepted as valuable however, these pathways are seen to operate in opposition to each other as cognitive persistence includes the element of cognitive control and cognitive flexibility is seen as being positively associated with distractibility (Dreisbach & Goschke, 2004).

This ‘either, or’ perspective necessitates a choice, and the most prevalent practices indicate that flexibility has been chosen above persistence (Goldenberg et al., 1999). (See Section 5.1.) Amongst researchers and academics too, there are those who see the more analytical, focussed cognitive style of the persistence pathway as being antithetical to creativity (Friedman & Forster, 2005).

While there is no apparent debate regarding the important role of cognitive flexibility in creativity, the persistence path has been found to present a viable alternative, such that creativity can also flourish in the absence of cognitive flexibility (Nijstad et al., 2010). Persistence is needed to overcome the path of least resistance that typically dominates thinking and mitigates against creativity (Ward, 1994). The default approach of problem solvers is to prefer less risky, unoriginal solutions (Mumford et al., 2020), implying that if creative solutions are required, problem solvers must be encouraged to think counter to their natural tendencies. It is suggested therefore, that the persistence pathway is an essential but under-utilized route to creative thinking.

When following the flexibility pathway, a broad focus is encouraged, as is reflected in measures of flexibility, in which creative performance is measured by the number of categories of ideas generated. Measures of flexibility and fluency, which refers to the total number of ideas generated, are well established measures of creativity, originally employed in the Torrance Test of creativity, and are still well used today. While there are arguments that these are measures of divergent thinking rather than creativity (Runco & Nemiro, 1994), the use of these measures persist – probably due to their ease of quantification and apparent objectivity.

The persistence pathway, on the other hand, requires disciplined attention within a narrow focus. In this focused mode, creative performance is measured as the number of ideas generated within a category (Nijstad et al., 2010). An individual in the focused mode, engaged in the persistence pathway, is therefore subject to less distraction (Dreisbach & Goschke, 2004) and will engage in in-depth exploration of a limited set of categories. This, however, implies that they are less flexible in their thinking. The dual pathway theory therefore posits that the two pathways represent alternative modes but that these modes cannot operate simultaneously.

5.2.4 The goal of the concentrated curiosity model: To simultaneously harness the synergistic benefits of flexibility and persistence

The model developed here is based on the premise that while the pathway of cognitive persistence and dogged, focused effort is often overlooked in practice when attempting to engage in creative problem solving, the simultaneous, albeit paradoxical pursuit of both persistence and its apparent opposite – the far more popularly pursued pathway of flexibility – is likely to optimise the potential benefits of both. The concentrated curiosity model represents an attempt to achieve this.

Research clearly indicates that creative thinking requires both well controlled thought processes and imaginative flights of fancy (Finke, 1996). Given the well demonstrated benefits of both approaches, it is suggested that if an approach could be developed to expedite the pursuit of both pathways, rather than having to choose one or the other, this would stimulate creativity more effectively than following either one of these pathways. Having to choose either the flexibility pathway or the persistence pathway is unlikely to yield optimal results as this requires passing up on the potential benefits of the road less travelled. Furthermore, there are interdependencies between the flexibility and persistence pathways. In order to generate original and useful solutions to complex problems, flexible thought processes must be able to draw on, combine, manipulate and be inspired by a sufficiently rich network of data points and concepts. Cognitive flexibility is far less likely to yield creative solutions when the landscape of cognitive material is arid, and cognitive persistence is needed to develop the requisite rich mental models (See Section 6.2.1). Using the persistence pathway in the absence of flexibility will also be less effective, as while persistent and focussed efforts to mine the problem space may uncover rich tracts of insights, flexibility is required to leverage and shape these insights into potential creative solutions.

The aim of the theory developed in this thesis is therefore to inform a normative framework that simultaneously and synergistically harnesses both the persistence and the flexibility pathways. This theory is therefore underpinned by paradox theory. The principle of the co-existence of conflicting paths is encapsulated in the definition of paradox as "...contradictory yet interrelated elements that exist simultaneously and persist over time." (Smith & Lewis, 2011, p.386).

Attempting to resolve the inherent tensions by treating the paradox as a dilemma and embracing one element at the expense of the other will inevitably entail a loss of the potential virtues of the discarded element. Furthermore, neglecting one element will inevitably highlight the virtues of the other (Lewis, 2000). Alternatively, value inherent in the differences will be lost by adopting a dialectic approach and attempting to synthesise opposing elements by focusing on similarities (Smith & Lewis, 2011). The theory developed in this thesis has therefore been designed to embrace the power of the paradox represented by the opposing pathways of flexibility and persistence.

6 THE DEVELOPMENT OF THE CONCENTRATED CURIOSITY THEORY AND MODEL

In the creativity research literature, there is strong evidence for both the roles of cognitive persistence (Boden, 1998; Guilford, 1982; Sternberg & Lubart, 1999; Weisberg, 2006) and cognitive flexibility (Csikszentmihalyi & Getzels, 1971; De Dreu et al., 2008; Miron Spektor & Beenen, 2015) in supporting creativity.

The dual pathway model in particular expresses the relative impact of these thinking styles and incorporates them into one theory that articulates that creativity is facilitated by following either of these paths (Nijstad et al., 2010). (See Sections 6.2 and 6.8 respectively.)

To develop a practical approach to harnessing both modes of thinking simultaneously, thereby harnessing the power in both, a literature search was conducted to identify approaches and modes of thinking that could lead to and support the sustaining of cognitive persistence and flexibility. The strategy was therefore to conduct a search for literature on cognitive persistence and flexibility in which clusters of related factors were discussed. These factors were then researched further to explore related factors, but to maintain focus, the scope of this search was limited to factors that would impact on the development of cognitive persistence and flexibility. In so doing, particular attention has been paid to behaviours rather than pre-existing attitudes or states as levers of creativity, given that there is a bi-directional relationship between behaviours and attitudes (Holland, Verplanken, & Van Knippenberg, 2002; Olson & Stone, 2005) and behaviours can be more actively shaped in order to induce the desired states or attitudes. As the intention was to develop this theory into a normative framework, the practical implications of the role that behaviours can play in influencing attitudes played an important role in informing the theory.

6.1 Overview of the concentrated curiosity model

This section develops a novel theory of problem construction that supports both the persistence and flexibility pathways described above.

As theories are broad and explanatory in nature, models provide more specific, applied explications of the relationships between constructs contained in the theory and predict effects (Fried, 2020; Martens, 2020). In order to express the predictions of the theory, the concentrated curiosity theory is therefore coalesced into the concentrated curiosity model depicted in Figure 3. The propositions and arguments that inform this model, as well as the literature that supports these, are expanded upon in the sections that follow.

One of the key stumbling blocks to creativity is the tendency to avoid effortful thinking by falling back on familiar patterns of thinking or adopting the first feasible solution generated (Caniëls & Rietzschel, 2015; Ward 1994). In organisations, when there are invariably time constraints, this tendency is likely to be exacerbated, as the solution that emerges first has the obvious merit of meeting time constraints, and default thinking is, by definition, tried and tested and less risky. The aim of this theory is therefore to ‘force’ the problem solver to overcome these naturally arising obstacles to creativity by digging deeper and pushing beyond more readily available solutions.

A proviso, however, is that this should be accomplished with a carrot rather than a stick, in order to establish and maintain intrinsic motivation. Furthermore, if the theory is to be harnessed for practical application, it should focus on leveraging factors that can be actively manipulated, such as behaviours, rather than psychological states, as discussed above.

The model described below has been developed by synthesizing and integrating findings and theories from the literature, as well as by proposing new approaches to the information search and problem framing.

The proposed approach to what has been termed an ‘interrogative information search’, is structured to stimulate the mindsets of curiosity, humility and open mindedness consistent with cognitive flexibility, by focusing on the questioning process – iteratively answering and generating questions in the course of the information search rather than noting facts. The approach proposed to problem framing is to break the problem down into a series of narrow frames, using the interrogative information search to extract the underlying concepts of which these narrow frames are comprised. This series of narrow problem frames are then addressed sequentially. It is hypothesized that this will create conditions conducive to cognitive persistence as each narrow problem frame will limit the range of possible solutions, necessitating a deeper search for alternative solutions.

The first theoretical proposition informing this model is that an interrogative information search will serve to facilitate creativity by initiating three causal processes. The first is by provoking curiosity, which enhances creativity by facilitating intrinsic motivation to engage with the problem, which in turn supports cognitive persistence (Csiksentmihalyi, 1988; Kashdan, Gallagher, Silvia, Winterstein, Breen, Terhar, & Steger, 2009; Schoutte & Madouff, 2020). The second is by facilitating the development of a more complex, granular, fluid mental model of the problem, which will facilitate conceptual combination (Dane 2010; Ericsson & Charness, 1994; Ericsson 1999; Weisberg, 2006). The third causal process proposed, is that the interrogative information search will support creativity by stimulating doubt, which in turn facilitates cognitive flexibility (Locke, Golden-Biddle & Feldman, 2008).

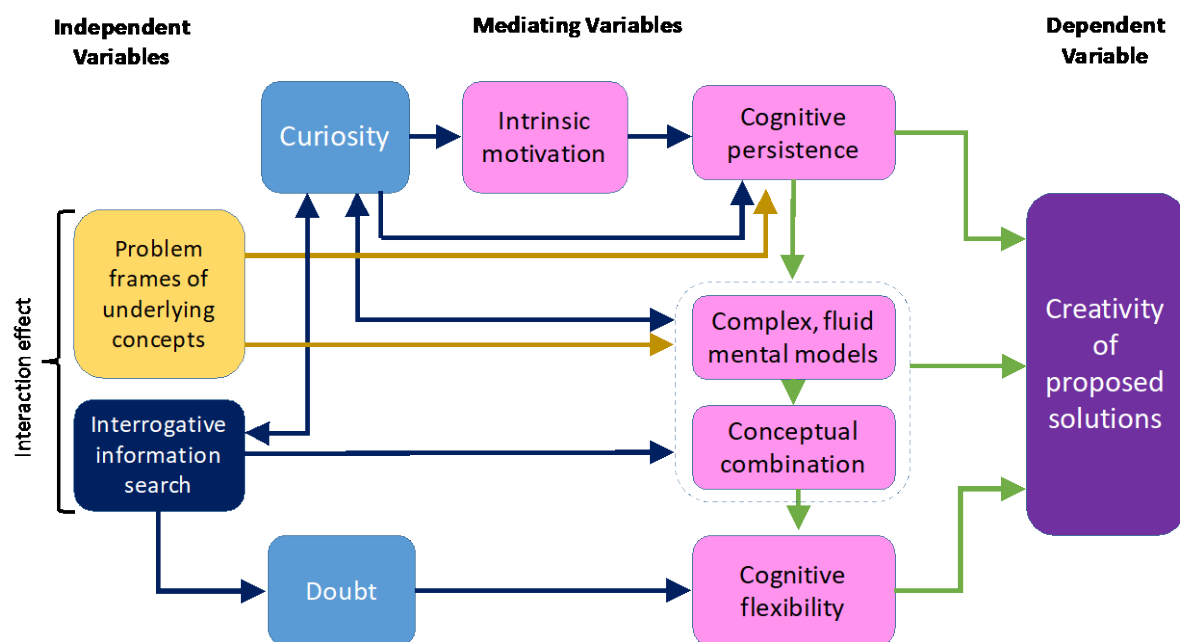
The second theoretical proposition is that focussing on the series of narrow problem frames facilitates cognitive persistence which is needed for the development of the complex, fluid mental models required to enable conceptual combination (Roskes, De Dreu, & Nijstad, 2012; Sagiv et al., 2010). It is also argued that focusing on a series of narrow frames, rather than one narrow frame, will serve to ward off the risk of fixation often associated with a narrow focus (Rietzel, Nijstad, & Stroebe, 2006).

A third proposition is that there is an interaction effect between the interrogative information search and the sequential use of narrow problem frames based on the conceptual map of the problem. Such narrow frames will allow for deeper and more focused exploration of the problem, which is associated with higher levels of creativity, especially in that it results in a higher proportion of better quality ideas being generated (Nijstad et al., 2010; Rietzel, Nijstad, & Stroebe, 2006; Taylor & Greve, 2006).

The model of the theory depicted in Figure 3 below has been named the ‘concentrated curiosity’ model as the intention is to both focus attention and activate curiosity, thus simultaneously stimulating both a concentrated focus and an open minded exploration to overcome the tendency to default to readily available solutions. It is proposed that the simultaneous application of constraints by constructing narrowly framed problems based on underlying concepts, and stimulation of curiosity through an interrogative information search, will lead to more creative solutions.

Figure 3

The concentrated curiosity model



In the model above, proposed causes of and relationships between states that precipitate both the persistence and flexibility pathways are articulated, with the intention of expressing the means whereby cognitive persistence and flexibility can be triggered to operate simultaneously and synergistically, as opposed to alternately.

Given that this combined approach is designed to stimulate both the persistence path and the flexibility path shown to be independently valuable in enabling creativity (Nijstad et al., 2010), the research question which is explored in this thesis is whether the combination of these approaches is associated with greater creativity of the solutions generated.

The rationale behind the hypothesised relationships and findings from the literature that support this argument are provided below.

6.2 Cognitive persistence – the unsung hero of creativity

The dual pathway theory presents both the persistence and flexibility pathways as alternative approaches to creativity, and while the aim of the concentrated curiosity model is to harness both of these pathways, given the popular as well as academic opinion that cognitive flexibility is essential to creativity (see Section 5.2.3) it is appropriate to emphasise the significant role that cognitive persistence has to play, despite its unwarranted status as the ‘poor cousin’ of creativity, as described in Section 5.1. It is suggested here, in fact, that if a key goal of creative thinking in organisations is to generate a solution that is both original and can be practically implemented to solve a complex business problem, the focused energy required by the persistence pathway may well be more fruitful than the flexibility pathway. Certainly, its role should not be over shadowed by the ubiquitous practice of the ‘crayons and beanbags’ approach to creativity. (See Section 5.2.1)

Alex Osborne, who originally developed the CPS process, considered lack of persistence to be one of the key reasons for failure in creative thinking (Rietzschel et al., 2006), and indeed there is strong evidence that creativity results from the deliberate, methodical approach to problem solving represented by the persistence pathway (Boden, 1998; Guilford, 1982; Sternberg & Lubart, 1999; Weisberg, 2006). The important role of cognitive persistence is also reflected in Sternberg and Lubart’s (1999) investment theory of creativity, which states that creative people are those who pursue an unpopular idea (buy low) and persevere with it until they have developed it, after which they move on to the next idea (sell high) (Sternberg, 1999). In popular business literature, however, this arguably conservative approach to creativity appears to be relegated to the margins (Grant 2016; Harford, 2016).

The alternative pathways of cognitive flexibility and persistence, are respectively negatively and positively associated with constraints.

As discussed in Section 5.2, there is conflicting evidence regarding the role of constraints, and accordingly, the dual pathway model illustrates that both freedom from and the imposition of constraints can both work as pathways to creativity.

Notably, however, some findings indicate that creativity does not flourish in the absence of any rules or constraints, as the problem solver will simply fall back on the most readily available solution (Caniëls & Rietzschel, 2015). Constraints are inherent in the focused interest, persistence and discipline that have been found to be key in creativity by researchers such as Dudek and Hall (1991), Roskes et al. (2012) and Sagiv et al. (2010). This could imply that cognitive persistence may be seen as a prerequisite for creativity, which requires pushing beyond the most readily available solutions. This suggestion is supported by results of a longitudinal study into values of creative as opposed to non-creative people conducted by Helson (1999) where productivity was found to be one of the distinguishing values. The most creative people in this study were found to be both focussed on productivity and highly persistent (Runco, 2006).

6.2.1 Cognitive persistence builds complex, fluid mental models

The value of complex, fluid mental models in creative problem solving is discussed in more detail in Section 6.5, but it is clear that cognitive persistence is required to build such mental models (Weisberg, 2006). Not surprisingly, a consistent positive relationship has been found between the expertise associated with complex mental models and both the amount and quality of deliberate practice across a number of fields (Ericsson, 1999). Cognitive persistence is, almost by definition, essential to deliberate practice. The executive control, focused and sustained attention that is involved in cognitive persistence is therefore a critical ingredient in building complex fluid mental models.

6.2.2 Approaches to enhance cognitive persistence

If the aim is to develop a methodology that enhances creative problem solving, a question that must be examined is whether and how cognitive persistence can be facilitated. Two strategies are proposed in the model. The first strategy is through inciting curiosity about the problem. Curiosity also leads to cognitive persistence indirectly via intrinsic motivation. The second strategy is by applying constraints in problem framing, such that problems are narrowly focussed on concepts within the broad problem frame. These strategies are expanded upon below.

6.3 Intrinsic motivation – an essential mediator of creativity

The central role of intrinsic motivation was a key contribution of Amabile's Componential Model of Creativity (Amabile, 1988). In fact, Amabile has been such a strong proponent of the role of intrinsic motivation that she asserted that without it, no "...recognizable level of creativity is to be produced." (Amabile, 1983, p. 367).

In fact, the role of internal motivation has come to be perceived as so significant that some see the impact of all contextual factors in an organisation as operating through intrinsic motivation (Shalley, Zhou, & Oldham, 2004).

While there is little argument about the need for intrinsic motivation in creativity, it is suggested here that, given its key function as a mediator of other states, thinking styles and behaviours (Steele, McIntosh, & Higgs, 2017) excessive focus on intrinsic motivation poses the potential risk of ignoring the significance of these other states.

6.3.1 The need to distinguish between freedom from constraints and intrinsic motivation

While in some respects freedom from constraints may create a conducive environment for creativity, findings that support this proposition are largely based on the impact of a lack of constraints on feelings of autonomy, which is positively associated with creativity though intrinsic motivation (Caniëls & Rietzschel, 2015).

Interestingly, it appears that despite more recent research indicating that constraints do not necessarily lead to decrements in intrinsic motivation, earlier literature which expressed this negative relationship has had a lasting impact on perceptions (Amabile, 1983; Osborne, 1963; Steele et al., 2017). For example, in her earlier work, Amabile (1983) argued that extrinsic constraints decreased intrinsic motivation, but revised her position on this in her later work (Amabile, 2018) based on her findings that extrinsic motivators, which also operate as constraints, can work synergistically to enhance intrinsic motivation. However, the legacy of the earlier conclusions regarding the role of constraints continues to exert a strong influence over organisational practice (Heslin, 2009; Caniëls & Rietzschel, 2015) as it frequently manifests in the tendency to concatenate the concepts of freedom from constraints and intrinsic motivation due to the widely held opinion that freedom from constraints is a key route to intrinsic motivation. It appears, moreover, that the putative requirement of freedom from constraints and the desired state of intrinsic motivation are sometimes so tightly linked, that they are expressed as concepts that inevitably operate hand in hand (Shalley et al., 2004).

It is a key argument of the concentrated curiosity theory, however, that a clear distinction must be maintained between these two concepts, as if it is held that the only approach to enhance intrinsic motivation is to create an environment of total freedom, the heavy price to be paid is the loss of potential benefits of strategically applied constraints in the creative thinking process. It is argued that this unintended concatenation is largely responsible for the prevalent reluctance to apply the constraints that would support cognitive persistence.

6.3.2 Potential approaches to increasing intrinsic motivation

While it is generally well accepted that motivation is a key factor in creativity, there has been much debate regarding the role that managers can play in increasing motivation.

In the development of thinking regarding the relative roles of extrinsic and intrinsic rewards, proponents of the ‘undermining effect’ argued that providing extrinsic rewards such as incentives for more creative outcomes, will undermine intrinsic motivation for the task by dampening the intrinsic interest in the task (Amabile, 1983; Deci & Ryan, 1995). Others subsequently suggested that when extrinsic rewards are applied correctly, namely with full disclosure that it is creativity rather than efficiency that is being rewarded, offering incentives for creativity can indeed enhance the creativity of outputs (Eisenberger & Rhoades, 2001). While the debate seems to have settled on the conclusion that extrinsic rewards can work synergistically with intrinsic motivation under some circumstances (Amabile & Pratt, 2016, Collins & Amabile, 1999; Ryan & Deci, 2000), the question of how to enhance intrinsic motivation has produced some interesting research but with few practical guidelines emerging. Offering rewards is still seen as potentially beneficial under some circumstances, but not in others. By way of example, rewards for creativity may be effective if the goal is to generate moderately as opposed to radically creative ideas, as rewards tend to motivate individuals to perform at a level that will warrant the reward, but will limit their vision regarding extending themselves beyond this level (Steele et al., 2017).

Managers are also advised to understand and attend to individual, contextual and task related differences so as to fine tune their approaches to motivate their employees (Steele et al., 2017). While in principle this approach has indisputable merit, the time pressures and limited managerial capacity so common in an organisational context present challenges to the practical application of these principles. Similarly, the progress principle put forward by Amabile and Pratt (2016) may be difficult to implement, as the principle is only said to operate when the individual perceives the work as meaningful, and for some tasks this may be challenging to engineer. While more practical direction is provided by Miron-Spektor and Beenen (2015), their claim that motivation and creative performance is enhanced by setting simultaneous learning and performance goals does not pertain to intrinsic motivation, but rather extrinsic motivation.

It is suggested in this model, that rather than attempting to increase intrinsic motivation to deliver a creative solution, such as via the application of goals or rewards, an alternative and potentially fruitful approach is to incite curiosity and interest in the problem to be solved. The link between curiosity and intrinsic motivation is explored in more detail in Section 6.4.1.

6.3.3 Intrinsic motivation drives cognitive persistence

One of the most important ways in which intrinsic motivation supports creativity, is through encouraging cognitive persistence (Amabile & Pratt, 2016).

Cziksentmihalyi (1988) in fact asserted that intrinsic motivation is the only reason for maintaining cognitive persistence and describes how intrinsic motivation is essential to persistence in the absence of a direct threat of punishment or reward. As the persistence pathway relies on a high degree of effort and is therefore more cognitively demanding than the flexibility pathway, the principle of energy conservation indicates that there will be reluctance to expend the necessary effort (Roskes, De Dreu, & Nijstad, 2012). The required focused attention and dedication to the task therefore depends heavily on intrinsic motivation to fuel and sustain such dedication.

In the Componential Model of Creativity, the prominence that the concept of intrinsic motivation receives, relative to cognitive persistence, is interesting in light of the indirect role of the former and the more direct role of the latter.

In expanding on the original version of the Componential Model, Amabile and Pratt (2016) take a further step back in the casual chain with their emphasis on the importance of progress in meaningful work, for which the term ‘the progress principle’ is coined. Its significance is explained as a condition that leads to intrinsic motivation in a bi-directional causal relationship, referred to as the ‘progress loop’, with intrinsic motivation in turn leading to the cognitive persistence required to make a creative breakthrough. This clearly underscores the importance of the role of cognitive persistence in creativity, and the indirect relationship that intrinsic motivation has with creativity – namely as a driver of cognitive persistence.

6.4 Curiosity: the lynchpin in creativity

It is proposed in this model, that curiosity is the lynchpin of creativity, due to its role in sparking intrinsic motivation in the problem, which in turn supports cognitive persistence, while simultaneously stimulating doubt, and subsequently, cognitive flexibility. Practical methods for instilling and deepening curiosity such that cognitive flexibility and cognitive persistence are sustained, are also proposed in the model. Findings that support these hypotheses and proposed casual relationships in the model are discussed below.

Curiosity is defined as “...the desire for new knowledge, information, experiences, or stimulation to resolve gaps or experience the unknown” (Grossnickle, 2016, p. 26). Curiosity has a multi-pronged role in creativity, suggesting that sparking curiosity would be valuable in driving creative problem solving. It is therefore appropriate to explore this concept in some detail.

Different types of curiosity are distinguished in the literature, using a number of classification criteria. Firstly, the criterion of stability is used in classifying curiosity as either a personality trait or a state triggered by the environment or context (Grossnickle, 2016; Lowenstein, 1994; Kashdan et al., 2004).

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Given that the purpose of this thesis is to develop an approach that can elicit creativity from a wide range of employees, whether they are naturally curious or not, the focus of this model is to trigger state curiosity.

Another criterion applied in classifying curiosity, is the motive for the state. A distinction is made between so called 'D-type curiosity, where the motive is to overcome feelings of deprivation and the goal is to resolve a gap in information, and I-type curiosity, for which the motivation is rooted in the desire to explore an area of interest (Grossnickle, 2016; Litman, 2005). D-type curiosity can be associated with mildly negative feelings such as frustration, whereas I-type curiosity and the exploration that emerges from it are said to be more pleasurable (Litman, 2005).

An alternative, but related distinction between sources of motivation uses the terms 'specific' and 'diversive' curiosity which are seen as being related to D-type and I-type curiosity respectively. Specific curiosity is goal directed and problem focused, with the aim of closing information gaps while diversive curiosity is described as more directionless and unfocused, with the primary purpose being to explore the unknown (Grossnickle, 2016; Hardy, Ness, & Mecca, 2017; Kashdan, et al., 2009; Loewenstein, 1994).

While Loewenstein (1994) wrote in relatively disparaging terms of diversive curiosity and clearly saw the more focussed version of specific curiosity as being more supportive of creativity, Hardy et al. (2017) found that diversive curiosity, mediated by the information search, was positively related to creativity, whereas no positive relationship could be detected between specific curiosity and creativity. Subsequently, however, Hagtevd, Dossinger, Harrison and Huang (2019) did find a predictive link between specific curiosity and creativity.

Given that diversive, or I-type curiosity is experienced as more pleasurable, it is suggested that the positive relationship between diversive curiosity and creativity could be explained by the capacity for diversive, or I-type curiosity to lead to intrinsic motivation to explore different potential solutions.

Hagtevd et al. (2019) hypothesise that specific curiosity plays a different role, in that the frustration experienced gets channelled into toying with different potential solutions when original ideas don't suffice.

It is proposed here that both diversive and specific curiosity are positively associated with creativity and the approach to framing questions utilised in the interrogative information search is therefore designed to elicit both. (See Section 6.6.1)

6.4.1 Curiosity leads to intrinsic motivation to explore the problem

In the concentrated curiosity model, curiosity is positioned as a key lever in sparking and supporting intrinsic motivation, cognitive persistence and the development of complex fluid mental models. Arguments that inform these proposed relationships are expanded upon below.

A The web of components of curiosity

Curiosity could be described as a complex web of interrelated elements, including emotional states or drives as well as behaviours. Loewenstein (1994) describes the early view of curiosity, adopted by thinkers such as Aristotle and Cicero, as an intrinsically motivated desire for information. He then describes how it subsequently came to be defined as a passion and an appetite, with a behavioural aspect being introduced into the prevailing view in the 1920's with research conducted by Pavlov. In the ground breaking work conducted by Berlyne (1958, as cited in Loewenstein, 1994), the conception of curiosity as including exploratory behaviour, was endorsed. A further development in conceptualising creativity was the incorporation of the trigger, such as the incongruity theorists' assertion that due to the inherent need for sense-making, curiosity will be triggered by the unexpected and unexplained (Loewenstein, 1994). White (1959, as cited in Loewenstein, 1994), asserted that the trigger stems from the need to master one's environment. This trigger leads to a state of arousal, which in turn motivates exploratory behaviour. Kashdan et al. (2009) assert that this exploratory behaviour is motivated by states that include openness to novel information and experiences and the willingness to actively engage with these, coupled with confidence in the ability to deal with information or contexts that are unfamiliar. Kashdan, Rose and Fincham (2004) and Kashdan et al. (2009) describe a further dimension to creativity – namely regulation of attention such that attention is focused on the new stimulus.

Four aspects of curiosity can therefore be identified, namely: a trigger, focus on the trigger, a state of arousal and exploratory behaviour – all of which are quite neatly encapsulated in the definition provided by Kashdan et al. (2018, p.130) as "...the recognition, pursuit, and desire to explore novel, uncertain, complex, and ambiguous events."

B The relationship between curiosity and intrinsic motivation

While, in the concentrated curiosity model, curiosity is distinguished from intrinsic motivation due to the relative ease with which the former can be provoked, opinions vary as to whether curiosity is a subset or a source of intrinsic motivation. For the purposes of the model this distinction is not material, as either definition indicates that sparking curiosity will generate intrinsic motivation, but it is nevertheless interesting to explore these arguments in the pursuit of a more nuanced appreciation of the phenomenon of curiosity.

Drawing on the finding that information is in itself rewarding, Oudeyer, Gottlieb and Lopes (2016) define curiosity as a form of intrinsic motivation. Ryan and Deci (2000) also see curiosity as a form of intrinsic motivation. Their definitions of intrinsic motivation as "...the doing of an activity for its inherent satisfactions rather than for some separable consequence" (Ryan & Deci, 2000, p.56) and "...the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn" (Ryan & Deci, 2000, p. 70), illustrate their position that there is little to no distinction between the two concepts.

On the other hand, Kashdan et al. (2009) argue that while curiosity shares some characteristics with intrinsic motivation, it also has some exclusive distinguishing characteristics – most significant of which is the propensity to extend one's understanding or experience beyond the familiar.

This distinction indicates that curiosity is indeed a phenomenon that exists outside of intrinsic motivation and is therefore a precursor to intrinsic motivation. Their proposed definition of curiosity is "...recognizing, embracing, and seeking out knowledge and new experiences" (Kashdan et al., 2009, p.988). Two additional proponents of the view that curiosity is a source rather than a subset of motivation are Grossnickle (2016) who notes that a common element in definitions of curiosity is the need to know, which serves as an internal source of motivation, and Litman (2005) who claims that it is the acquisition of new information rather than the curiosity itself that serves as the intrinsic reward.

Arguments regarding the source of motivation still prevail, as do arguments regarding the nature of the arousal state, with some contending that the state is unpleasant, leading to a need to engage in exploratory behaviour to relieve the negative state of arousal, and others holding that the arousal state is enjoyable, motivating exploratory behaviour that is intrinsically satisfying. (Litman, 2005). Kashdan et al. (2004) conclude that curiosity may be experienced as either enjoyable or unpleasant, and again, for the purposes of the concentrated curiosity model, this is not material.

C *Curiosity's bi-directional feedback loop between state and behaviour*

What is key for the concentrated curiosity model, is the incorporation of the behavioural component described above. Grossnickle (2016) determined that 64% of definitions of curiosity include the motivational role of curiosity in exploratory behaviour. For example, Litman (2005) integrates views of Berlyne, (1949, 1960), Collins, Litman and Spielberger (2004), Litman and Jimerson (2004), Litman and Spielberger (2003) and Loewenstein (1994), in the definition of curiosity as "...a desire to know, to see, or to experience that motivates exploratory behaviour directed towards the acquisition of new information" (Litman, 2005, p.793).

It is this behavioural element inherent to curiosity which in fact distinguishes curiosity from other similar concepts such as openness to experience (Kashdan et al., 2004).

As curiosity is clearly comprised of an interrelated network of states and behaviours with feedback loops, and an active state that includes exploratory or information seeking behaviour, it is argued here that engaging in these behaviours would provide an effective route to invoking the allied state of intrinsic motivation. This argument is based on the theory of emergent motivation, which states that behaviours give rise to emergent motivation, even if the individual engaged in the behaviour did not have a prior motivation to pursue this issue (Csikszentmihalyi, 2014; Nakamura, Dwight, & Shankland, 2019). Therefore if the goal is to spark interest in the problem and intrinsic motivation to generate creative solutions to this problem, initiating curiosity, which involves exploratory behaviour, is likely to be an effective approach.

6.4.2 Curiosity leads to cognitive persistence

In addition to increasing intrinsic motivation to explore the problem to be solved, which in turn supports cognitive persistence, curiosity also leads to cognitive persistence directly, as it directs attentional resources to the task at hand and motivates more expenditure of effort (Kashdan et al., 2004; Silvia, 2006). Curiosity therefore leads to exploration for its own sake, as this exploration is found to be intrinsically motivating and encourages sustained focus on the problem (Litman, 2005; Schutte & Malouff, 2020).

6.4.3 Curiosity supports the development of complex mental models

The role of curiosity in supporting the development of complex, fluid mental models by motivating the cognitive persistence required to build such complex models is described in Sections 6.2.1 and 6.4.2. However, it is proposed that there is also a more direct causal relationship between curiosity and complex mental models. This is supported by findings that curiosity supports the integration of new information in such a way that new inputs are also retained more effectively (Kang et al., 2009; Oudeyer et al., 2016).

Silvia (2006) also holds that curiosity leads to the deeper processing of information that allows for more complex mental models. Moreover, newly induced curiosity in the subject appears to also be more strongly associated with deeper and more active information processing than a pre-existing interest in the subject.

This is implied by findings that a pre-existing interest in the subject of the problem may in fact dull information processing as the individual is motivated to selectively process information that endorses their existing mental model (Illies & Reiter-Palmon, 2004; Russo, Medvec, & Meloy, 1996).

6.5 Conceptual combination – drawing on complex, fluid mental models

Conceptual combination involves extraction of key concepts from the problem and combining them in alternative, original ways (Hunter, Bedell, & Mumford, 2006). One of the most significant potential outcomes of conceptual combination is that it can yield novel emergent features (Ward & Kolomyts, 2010), which implies that not only does it generate alternative perspectives but, in itself, may yield inputs to creative solutions. There is a high level of consensus that of all processes and thinking styles, conceptual combination may be the most significant in enabling the generation of creative solutions (Hunter et al., 2006; Mumford, 2000; Reiter-Palmon & Illies, 2004; Ward & Kolomyts, 2010; Ward, Patterson & Sifonis, 2004). It therefore follows that conceptual combination appears in a number of process models of creative thinking (Mumford, Baughman, Maher, Costanza & Supinski, 1997; Mumford & McIntosh, 2017; Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991).

When conceptual combination is utilized in creative thinking, it has been found that solutions are of higher quality and are more original and elegant (Mumford, Supinski, Baughman, Costanza, & Threlfall, 1997; Scott, Lonergan, & Mumford, 2005). Accordingly, skills in assembling and reorganizing concepts were found to be one of the best predictors of creative performance (Mumford, Baughman, Maher, Costanza, & Supinski, 1997; Ward et al., 2004).

If conceptual combination plays such a key role in creativity, an important line of enquiry is to determine conditions that best facilitate this process. Given that the retrieval and activation of knowledge provides the foundation for conceptual combination, it follows logically that the more knowledge available for activation, the greater the potential and opportunities for conceptual combination (Malycha & Maier, 2017). This implies that deep and extensive knowledge of the domain, reflected in rich mental models, should be an asset in creative thinking.

Mental models are mental representations of the surrounding world and explain an individual's thoughts about how things work in the world (Malaycha & Maier, 2017). As such, they include an articulation of both concepts and relationships between these concepts (Hester et al., 2012; Malaycha & Maier, 2017). Given that they provide a framework for storing and recall of experiences, these complex cognitive structures influence people's thinking by directing attention (Malaycha & Maier, 2017).

They therefore not only represent a network of concepts and relationships but serve to actively channel and interpret knowledge and experience. Experts are said to have more complex and detailed mental models which comprise both more concepts and more complex relationships, making them more accurate (Dane, 2010).

Complex mental models also provide a far richer network of possible concepts to combine and reorganise, which enables greater potential variation in conceptual combination. This underpins the view that complex mental models are critical in creative thinking (Dane, 2010; Mumford et al., 2006).

From the discussion above, it would appear to be a logical conclusion that the development of complex mental models would be an important ingredient in a creative problem solving methodology. However, there are opposing views regarding the value of domain expertise and the associated complex mental models, which are discussed below.

6.5.1 Arguments regarding the role of domain expertise in creativity

In reviewing the role of complex mental models in creative problem solving, it is important to note the controversy regarding the role of domain expertise in creativity. There is a considerable body of evidence that supports the view that there is a positive relationship between domain expertise and creativity in that specific domain (Amabile, 1996a; Baer, 2015; Nijstad & Stroebe, 2006; Simonton, 2015).

It is established from these studies that having some knowledge and experience in a domain will provide a base from which creative ideas can be developed. Strong proponents of domain expertise such as Baer (2015) and Weisberg (2006) assert that creativity is not even possible without domain expertise. Baer (2015) contends that an individual's creativity is always domain specific, and claims, furthermore, that if an individual is an expert in a particular domain, they are more likely to be creative in this domain. He argues convincingly that "Ignorance is rarely, if ever, an advantage" (Baer, 2015, p.174).

There are, however, some directly opposing arguments as to whether domain expertise, and the resultant complexity of a mental model, enables or impedes cognitive flexibility and creativity. Studies such as the historiometric research by Simonton (1983) indicate that the relationship between expertise and creativity can be described as an inverted u, with greater expertise being correlated with greater creativity up to a point, whereafter creativity starts to decline with an increase in expertise. Runco and Nemiro (1994) expressed this point as being a situation where too much knowledge may lead to tunnel vision. An argument proposed to explain this 'tunnel vision' is that high levels of expertise can increase the degree of inflexibility in thinking, (Lewandowsky, Little & Kalish, 2007; Sternberg, 1996; Wiley, 1998).

Wiley (1988, p.728) explains this opinion with the claim that "... experts tend to consider *less* information than do novices in their problem solving."

Those who argue that experts' complex mental models are an impediment to flexibility suggest that expertise can lead to rigid rather than flexible thinking when well developed mental models are so established and stable that they resist manipulation (Dane, 2010). De Bono (1993) also argues that too much information thus results in reverting to existing solutions. Dane (2010) uses the term 'cognitive entrenchment' to describe this phenomenon, and asserts that the domain knowledge of experts may increase their ability to develop ideas that are incremental in the level of novelty, but may limit their ability to generate more radically creative ideas. He hypothesizes that experts' complex schemas may be stable due to frequent access to these schemas.

There is a body of evidence, however, that in fact the opposite is true, and that after immersing themselves in their subject matter due to practice and experience, experts, or those who have developed complex mental models of a particular domain, can and do tend to exercise greater cognitive flexibility and draw on more knowledge resources. (Ericsson, 1999; Weisberg, 2006).

6.5.2 How complex mental models enable cognitive flexibility

In his studies on expert performers, Ericsson (1999) amassed strong evidence that experts' complex mental models enable cognitive flexibility by providing them with ready access to a range of information such that they can retrieve information most relevant to the given situation, thereby allowing for selection of a response from a more extensive range of options. The broader range of available responses amongst experts then enables more original responses as they "...initiate the independent pursuit of original contributions to the domain." (Ericsson, 1999, p.331)

While, as described above, Dane (2010) cautions against the potential stability of experts' complex schemas, he notes that fixation occurs only in some instances amongst experts, and that novices may also experience cognitive entrenchment, especially when operating under stressful conditions. It could be argued, in fact, that novices' underdeveloped mental models may be the cause of greater inflexibility, as fewer concepts and relationships within a schema allow for fewer permutations.

This argument is supported by results of a study amongst novice and expert teachers, which showed that novice teachers were more inflexible in their approaches to problems whereas experts, or those with more developed schemas, applied rules and routines with greater flexibility (Schempp, Tan, Manross, & Fincher, 1998). Novice teachers also had a lesser ability to appreciate individual differences between students, suggesting that expert teachers have a more nuanced perspective. More experienced teachers also consistently looked for better, new ideas.

Interestingly, teachers with more expertise had less confidence in the completeness of their own knowledge than novice teachers. It is suggested that one might better appreciate the need for humility when one has a better grasp of the vastness and complexity of a subject.

Similar results were found in a study in the field of chess conducted by Bilalić, McLeod and Gobet (2008) who found that while some expert chess players did demonstrate inflexible thinking, those with the highest levels of expertise exhibited more flexible thinking than novices. These results echoed those of research conducted by Charness (1981), who found that expert chess players sought out more alternative moves. In fact in contrast to the theory and some research findings indicating that expertise might inhibit cognitive flexibility and creativity, "...the naturalistic study of experts suggests that the greater their level of expertise the more flexible and creative their thought patterns will be." (Bilalić et al., 2008, p.30)

6.5.3 Types of complex mental models that are more conducive to creativity

While complex mental models are usually associated with domain expertise, (Dane, 2010; Malaycha & Maier, 2017) the arguments described above indicate that not all domain expertise is associated with enhanced creativity. It is therefore suggested that while the complexity of mental models might be intrinsic to expertise, mental models may differ in ways other than their complexity, and it is these features which facilitate or hinder creativity.

The various research findings described in Section 6.5.1 suggest that to support creativity, a mental model needs to not only contain a sufficiently detailed depiction of concepts and relationships between them, which would constitute a complex model, but also 'store' these concepts in such a way that they are not rigidly grouped, but rather enable fluid access. In the model described in Figure 3 above, such a mental model is referred to as a complex, fluid mental model.

The source of the knowledge that informs the mental model plays an important role in influencing its fluidity. Case based knowledge, for example, is based on experience, where one stores a prototype of each problem. While this may include deviations from the standard, in order to work from this platform to generate creative solutions, a deep analysis and alternative framing of concepts is required, but given that this knowledge is based on the situational experience, it is likely to be less malleable (Hunter et al., 2006). Mumford et al. (2020) also caution that a potential impediment to creativity arises when experts rely on the mental models they have built based on their case experience, to the extent that they neglect to integrate concepts into these schemas.

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In contrast, schematic knowledge, while harder to acquire than case based knowledge, is based on understanding the underlying concepts and principles of a phenomenon or situation, as well as the relationships between them (Hunter et al., 2006), and is therefore likely to yield more fluid mental models.

A related factor that contributes towards the fluidity of mental models is the level at which underlying concepts are defined. Fluid rather than static mental models of a problem are based on abstract principles or concepts rather than concrete examples (Ward et al., 2004). It has been found that proposed solutions are more original when abstract information is accessed, but may be more practical when more specific information is accessed, and given the dual requirements of originality and practicality for a creative solution, it therefore appears that accessing multiple levels of abstraction may be preferable (Ward & Kolomyts, 2010). To build mental models that fuel both original and useful solutions therefore, it is suggested that the information should be processed so as to extract concepts from more concrete examples. (See Section 6.6.3)

In fact, the benefits of using analogies in creative problem solving (Scott et al., 2004) may well be based on the value of incorporating abstract rather than concrete concepts in mental models. As expressed by Gentner and Maravilla (2018, p.186), “Analogies thus capture parallels across different situations. The elements that belong to the two situations need not be similar, but the relations that hold the systems together must be alike.”

The benefit of analogical thinking to solve a complex problem may therefore be derived from the role that analogies play in facilitating insights into the underlying concepts and relationships between concepts, while liberating the schema from its context.

A mental model that is based on a detailed causal analysis will also support creative thinking (Hester, et al., 2012; Mumford et al., 2020). The inclusion of a greater number of concepts and identification of different kinds of causal relationships between concepts will also be valuable (Hester, et al., 2012). The level of granularity is therefore an important factor that will support fluidity and mitigate against the schema being used as a gestalt.

In summary therefore, in order to support the cognitive flexibility required for creative thinking, mental models of the problem should not only be complex, through the inclusion of sufficient detail on concepts and relationships between them, but also, to ensure their fluidity, be based on concepts derived from schematic knowledge. Such complex, fluid mental models provide rich fodder for conceptual combination, thereby performing a key role in enabling the generation of creative solutions.

6.5.4 Proposed approach to developing complex, fluid mental models

As discussed in the overview of the theoretical principles informing the model in Section 6.1, it is suggested that an alternative approach to looking for information about the problem, namely on interrogative information search, combined with the formulation of narrow problem frames will support the development of mental models that are not only complex, but fluid. It is proposed that this approach will support the development of a sufficiently complex and fluid concept map of the problem and encourages deep and active analysis of the overall problem space. The arguments supporting this proposition are described in the sections that follow.

6.6 The interrogative information search

As discussed in Section 4.4.2, there are few studies that focus on the search for information about a problem, although it is acknowledged as one of the three sub-stages within problem construction. This gap is surprising, as the human capacity for creativity *ex nihilo* is limited at best, such that new ideas are born from working with existing knowledge (Ward, 2004). If knowledge could be described as the raw material used in developing new ideas, it follows logically that creativity depends on the extent and quality of knowledge about the problem. Building knowledge requires the search for information and it could be argued that in this context, quality could be defined as the extent to which knowledge can be leveraged for creative problem solving (Oxman, 2004). This depends on the way in which it is stored – namely, in complex, fluid mental models (See Section 6.5). It is therefore reiterated that the information search in the context of creative problem solving merits deep investigation.

Findings of the little research that has been conducted into this topic indicate that not only is information search positively associated with the creativity of outcomes, but it is the way in which information is processed that is key, with active processing of information being most significant for creativity (Harms et al., 2018; Illies & Reiter-Palmon, 2004; Mumford, Baughman, Supinski & Maher 1996; Steele et al., 2017). The simple collection of data is unlikely to meet this requirement for active processing.

The alternative approach to the information search proposed here, has been designed with two key goals in mind: firstly to spark curiosity about the problem and secondly to develop complex, fluid mental models of the problem. While information searches are typically, as the term implies, geared towards discovering facts or information to plug gaps in knowledge, an alternative approach has been proposed, whereby the goal of the information search is to focus on continual questioning and probing with the aim of both generating and answering questions. For ease of reference, the term ‘factual information search’ will be used here to refer to the traditional information search and the term ‘interrogative information search’ will be used to describe this alternative proposed approach.

Given the valuable role that the information search plays in supporting creativity, it is important to examine how to motivate problem solvers to take the necessary time to search for information before seeking solutions. Of course there is the inherent joy of discovery to be derived from the process of looking for and finding information (Cziksentmihalyi, 1985), but the aim of the interrogative information search is not only an end goal of discovery, but rather the process of searching and discovering so as to prompt ongoing questioning which prompts new or deeper searches. The focus of the interrogative information search is therefore the questioning process, rather than the collection of data. Each stage of the process should build on the previous stage such that the search is extended to encompass both a broader range of insights as well as deeper investigation of the relevant issues. In this way, the appreciation of the problem space is extended in two dimensions, as depicted in Figure 4 below.

Figure 4

The broadening and deepening spiral of the interrogative information search



In this figure, the iterative nature of the interrogative information search is depicted as a spiral in which questions posed lead to the collection of facts in response to these questions, following which additional questions are posed in a continual process. From a position at the top of the spiral, in which the insights about the problem are narrow in scope and superficial in depth, the process of continual questioning in response to the collection of facts leads the problem solver to both broaden and deepen the range of insights gleaned.

While a structured search methodology implies applying certain constraints (Rosso, 2014), as opposed to adopting a laissez faire approach to the search process, the argument for employing constraints in the search process is to encourage a level of rigour. The application of constraints is therefore not intended to restrict the range and depth of information generated, but rather to extend it.

It is proposed that such a methodology will facilitate more active processing of information to develop more granular, malleable mental models. The rationale for this proposition is discussed below.

6.6.1 Role of the interrogative information search in sparking curiosity

Curiosity has been shown to have a positive effect on creativity, mediated through an information search (Hardy, Ness, & Mecca, 2017). The interrogative information search is designed to promote this state in the ways described below.

A Questioning leads to curiosity

Two fundamental premises for using an interrogative information search to boost levels of curiosity in the problem are firstly, that posing a question that alerts the individual to missing information will induce curiosity, based on the need to close the gap in knowledge (Grossnickle, 2016; Litman, 2005), and secondly, that increasing levels of knowledge about the problem are likely to heighten levels of curiosity (Grossnickle, 2016). The interrogative information search is therefore designed to support this virtuous cycle that builds both insights and curiosity about the problem.

An individual's interest in the subject of the problem is not a given but can be invoked, as shown in research conducted by Kashdan et al. (2004) which yielded the finding that curiosity is malleable and can be influenced or stimulated by external or internal stimuli or conditions. Simply put, the act of questioning enhances curiosity (Alaimi, Law, Pantasdo, Oudeyer, & Sauzeon, 2020).

B Autonomy in questioning supports the development of curiosity

Research findings also indicate that the use of one's own discretion and the exercise of autonomy in identifying questions of interest to the individual, are likely to deepen curiosity and interest and ignite more active processing of information (Cordova & Lepper, 1996; Kashdan & Fincham, 2004; Ryan & Deci, 2000). The role of autonomy in building the intrinsic motivation to explore the problem, so closely allied to curiosity, is also supported by the Self Determination Theory of Ryan and Deci (2000).

The interrogative information search therefore allows problem solvers sufficient autonomy to select questions that are of interest to the individual.

In so doing, questioning allows for more active involvement in the subject of the problem, as rather than submitting to the implicit acceptance of an author's curation of available material, active questioning invites the individual to exercise their choice in pursuing aspects that are of interest to them. Therefore, while guidelines are provided to facilitate deeper questioning, the fact that the individual can select and shape questions that reflect their interest, is likely to increase their curiosity.

C *An increase in knowledge leads to an increase in curiosity*

The exploratory behaviour that is intrinsic to curiosity and its relationship with the arousal state is described in Section 6.4.1 above, and the interrogative information search is designed to leverage this bi-directional causal relationship.

In addition to the questioning process, the information gleaned in the process of the interrogative information search itself is likely to provide an important stimulus to curiosity. Having some knowledge of the subject matter has been shown to be an essential ingredient of curiosity (Loewenstein, 1994), and based on the information gap theory of curiosity, curiosity is highest when an individual has some information but not too much to feel overly confident in their knowledge of the subject (Loewenstein, 1994; Kang et al., 2009). “If curiosity is like a hunger for knowledge, then a small “priming dose” of information increases the hunger, and the decrease in curiosity from knowing a lot is like being satiated” (Kang et al., 2009, p.963) As the interrogative information search is based on the cycle of questioning, answering and then further questioning, answers provide the appetiser of information, while the questions indicate that there is more to be discovered, such that the knowledge provided is incomplete.

The findings described above have the interesting implication that curiosity increases with knowledge, as more knowledgeable individuals are more likely to appreciate that there are gaps in their knowledge. Furthermore, the gain in knowledge reduces the information gap, and smaller information gaps are related to higher levels of curiosity, as in the ‘tip of the tongue’ phenomenon, where the individual feels that the missing information is just slightly beyond his or her reach (Loewenstein, 1994). These findings suggest that engaging in the self-directed exploratory behaviour of an interrogative information search will not only spark curiosity, but perpetuate it.

6.6.2 *Role of the interrogative information search in encouraging novel perspectives*

The focus on questions is also used to encourage the problem solver to see the material from an unfamiliar perspective. While novelty may be actively embraced, having to confront the unfamiliar also provokes a self-assessment of the ability to cope with the inherent challenges, such that there may be resistance to adopting a novel perspective (Kashdan et al., 2009; Silvia, 2005).

Given that a lack of perceived control causes and exacerbates anxiety, an autonomous approach to learning also serves to mitigate the anxiety invoked by novelty. The autonomy that the problem solver is able to exercise in selecting and tailoring the most relevant questions should endorse the sense of control in actively eliciting new information.

While novelty may provoke anxiety, it can also act as a motivator. The phenomenon of neophilia, or the tendency to seek out new and surprising information, has been demonstrated in neuroscientific studies of both animals and humans, indicating that the experience of acquiring new information can be rewarding in and of itself (Oudeyer et al., 2016). The fact that the interrogative information search is structured to encourage the problem solver to focus on aspects of the problem that may be new or surprising, may therefore be inherently rewarding.

It is also worth noting the views of Berlyne (1960) and Lowenstein (1994) who caution that novelty should be 'intermediate' in order to attract attention, as novelty that is relatively extreme may be avoided. The interrogative information search therefore employs a gradual, iterative approach to the introduction of new information, as questions are posed off the back of newly assimilated information.

6.6.3 Role of the interrogative information search in building more complex, fluid mental models

As discussed above, if the goal is to build a mental model of the problem that is both complex and fluid, and given that an information search is required to populate the complexity of the mental model, a question that emerges is how to structure the information search such that fluidity is ingrained in the model in tandem with the increase in complexity.

As discussed in Section 6.5, the complexity of a mental model depends on a rich and detailed understanding of the domain. As knowledge can either be seen as a fundamental ingredient of domain expertise (Lewandowsky et al., 2007) or even equated with expertise (Weisberg 2006), the search for information is clearly critical in populating the model with the relevant detail. Considering this clear dependency, it is interesting that while there is such a substantial body of research on the role of domain expertise in creativity, so little research has been conducted into the role of information search in creativity.

Findings of the few studies that have been conducted on the role of the information search in creativity highlight the importance of analysing and unpacking incoming data before storing it, such that principles rather than facts are distilled and incorporated into the schema (Mumford, 2000).

While there is little argument that searching for information about a problem before attempting to generate solutions will result in more creative solutions (Mumford, Baughman, Supinski, & Maher, 1996), the importance of active processing also supersedes the time spent on information search (Illies & Reiter-Palmon, 2004; Mumford et al., 2020).

If information is not actively processed, it is either used solely to endorse the current mental model, or, if incoming information is not aligned with the current mental model, it is simply ignored (Russo et al., 1996). A potential barrier to active processing that merits consideration, is that if the problem is tied up with an individual's values, they may approach it with a closed mind. To encourage active processing therefore, it is insufficient, and in fact may be counter-productive to simply increase time and effort spent on the information search (Illies & Reiter-Palmon, 2004). Rather, what is required is a search methodology that supports active processing regardless of the problem solver's personal attitude to the problem.

Conducting the interrogative information search demands effortful processing of information, such that even incoming information that is consistent with the current mental model is reviewed for additional insights, rather than simply used to endorse the existing perspective on the problem, and incoming information that is contradictory will be explored and interrogated rather than rejected. It is proposed therefore, that structuring the information search such that incoming information is used as a springboard for new questions, rather than storing answers as facts, will result in more thoughtful, active processing of information. This proposition is supported by findings that composing questions facilitates focus on the most relevant issues (Brown, Palincsar, & Armbruster, 1984).

It is also argued that fluidity of mental models will be reinforced by the inevitable cycling between different perspectives as both the complexity of the problem and the nature of problem solvers' interactions with it, are explored. The soft systems perspective is that the process of learning about complex problems is, in itself, systemic, as the aim of representing problems is not to reflect an external reality but rather to explore it through the process of depicting it (Checkland, 2000; Taket & White, 1997). This view aligns with the emphasis of the interrogative information search, which the questioning process rather than the end result of collecting facts.

A Facilitation of principle-based thinking

As both lower and higher order levels of abstraction are useful in supporting the generation of creative solutions (see Section 6.7.3), certain questions in this framework are also posed to channel more abstract thinking by directing the problem solver's thought processes away from the specifics of the problem and towards the underlying principles. This is based on the finding that thinking about the problem in more abstract and less contextually bound terms leads to more creative solutions. (Kokotovich, 2008; Ward et al., 2004; Ward & Kolomyts, 2010).

B Supporting fluidity through doubt

A mental model in which questioning and, by implication, doubt, are embedded, is also likely to be a fluid one. (See Sections 6.5.3 and 6.9).

It is therefore proposed that the multiple possible paths of thought which the interrogation can expose, in which component parts and relationships between them are questioned, is likely to support the development of a mental model that is not only complex, but fluid.

6.7 Narrow frames: problem framing using concept mapping

Against the background of broad consensus on the significance of the role of problem framing and findings that active involvement in problem framing enhances the creativity of solutions proposed (Basadur et al., 1982; Redmond et al., 1993; Reiter-Palmon, Mumford, O'Connor Boes, & Runco, 1997; Reiter-Palmon & Robinson, 2009), it is noteworthy that opinions on the optimal approach to problem framing are, in many cases, diametrically opposed.

In particular, the relative effectiveness of narrowly framed versus broadly framed problems has been the subject of several studies, with conflicting results. Some findings indicate that a broad focus is more conducive to creativity as it enhances flexibility in thinking (Friedman, Fishbach, Förster, & Werth, 2003; Shalley, Hitt, & Zhou, 2015). Even some of those who support introducing structure and constraints into the creative process argue for the use of a broadly framed problem to start off the creative process (Finke et al., 1992). There are also, however, many proponents of the opposite view. Despite the prevailing popular opinion that creativity thrives in an unconstrained environment, there is a substantial body of evidence that narrow rather than broad problem frames result in the generation of more creative solutions (Coskun, Paulus, Brown, & Sherwood, 2000; Dennis, Valacich, Connolly, & Wynne, 1996; Deuja, Kohn, Paulus, & Korde, 2014; Ho, 2001; Liikkanen & Perttula, 2009; Rietzschel, Nijstad, & Stroebe, 2007; Sagiv et al., 2010; Tromp, 2024).

An attempt to offer a perspective to resolve these arguments has been offered by Mumford et al. (2020) who propose that while constraining the focus of problem frames is necessary when tackling complex, ill-defined problems, too many constraints or the wrong kind of constraints can have a detrimental effect on creativity.

Bearing these arguments in mind, the approach to problem framing adopted in the concentrated curiosity model is to deconstruct the broad problem into a number of sub-problems, with frames being based on these sub-problems, enabling narrow framing of the problem. Identification of the concepts embodied in these sub-problems, as well as the relationships between these concepts, are visually represented in a networked concept map. Narrow problem frames depicted in networked concept maps are then addressed sequentially.

While there is clearly sufficient evidence to argue for the use of narrow frames, the application of this approach in the concentrated curiosity model serves a specific purpose – namely to work in counterpoint to the interrogative information search, which is designed to encourage more open ended exploration.

Given that the purpose of the concentrated curiosity model is to stimulate both a deep, focused examination of the problem as well as a broadly meandering exploration of alternative perspectives, the role of the narrow frames is to enforce a concentrated, effortful investigation of the limited problem space.

Arguments supporting this position are described below.

6.7.1 The argument for narrow problem frames

A narrowly defined problem is one which focuses on a sub-problem of the broad problem and therefore has a constrained scope (Dennis et al., 1996).

As described above, supporters of broad problem frames argue that cognitive flexibility is greater when the focus is broad (Friedman et al., 2003; Shalley et al., 2015). It is indeed accepted that a narrow problem frame is more strongly associated with the persistence path and negatively associated with cognitive flexibility, as it does not allow for the ease of switching between alternative approaches within the problem frame due to the discipline and executive control required to maintain focus within the narrow range (Nijstad et al. 2010). However, given the arguments described below regarding the benefits offered by a narrow frame, it is worth questioning whether the potentially lower level of cognitive flexibility typically associated with a narrow frame has the net effect of making it less conducive to creativity than a broad problem frame. While a broad frame may indeed yield a greater range or number of solutions, arguments supporting the narrow problem frame indicate that the set of solutions yielded by a narrow frame is likely to contain a greater proportion of more creative solutions, even if the total number of ideas generated is lower.

It is noteworthy therefore, that a review of the methodology employed by Friedman et al. (2003) reveals that in these experimental studies, creativity was defined using only the dimension of originality rather than both originality and utility, which are generally accepted criteria in the definition of a creative solution (Barron, 1955; Runco & Jaeger, 2012). In fact, in selecting an example of a creative use of a brick, the authors cited the proposed idea that the brick could be ground up and used as make-up, which may be a relatively original idea, but its practical value is questionable. Given that both originality and practical utility are intrinsic to the definition of creativity, it is suggested that their conclusions that a broad problem frame supports more creative solutions, could be questioned.

In the concentrated curiosity model, the aim is to harness the following particular potential advantages of using narrow problem frames.

A Focusing on narrow problem frames may elicit cognitive persistence

While a more broadly constructed problem may possibly generate a greater breadth of ideas, a more narrowly constructed problem is said to generate a greater depth of ideas (Nijstad, Stroebe, & Lodewijk, 2002). Such ‘depth’ may refer to both originality and utility, or a combination of the two, as a broad problem frame may enable easier access to a greater number of potential solutions, such that the problem solver can rely on cognitively available solutions and does not have to search for solutions beyond these. A narrow problem frame, on the other hand, necessitates a deeper search as available ideas are limited. This implies that a higher level of cognitive persistence is demanded when attempting to generate solutions to address narrowly framed problems, due to the greater need to explore the given frame in depth. Typically it is the conventional ideas that are more cognitively available, implying that the ideas that are more hard won through greater cognitive persistence are likely to be more original (Dreisbach & Goschke, 2004; Koch, Holland, & van Knippenberg 2008; Nijstad et al., 2010; Rietzschel, Nijstad, & Stroebe, 2014).

B Focusing on narrow problem frames may support the development of complex mental models

A further potential relationship extrapolated in part from these findings, and noted in the graphical depiction of the model depicted in Figure 3 is the negative relationship between the breadth of the problem frame and the complexity of the mental model of the problem, due to the reduced tendency to explore the domain in the same depth as would be the case for a narrower problem frame. A narrow problem frame might therefore be more conducive to the development of greater domain expertise and more complex mental models due to the relative ease of becoming an ‘expert’ within the limited scope of subject matter (See Section 6.5).

6.7.2 Benefits of sequential focus on a series of narrow frames

It is proposed that sequential focus on a series of narrow frames ultimately facilitates focus on a broader frame than would be the case by simply using a single broad problem frame. The rationale for this assertion is that with a single broad problem frame, attention may be dedicated to a particular aspect of the problem that leads the thinking in a particular direction. On the other hand, by intentionally focusing attention on different aspects of the problem in turn, each aspect identified upfront is likely to receive dedicated attention, even if it does not immediately appear to present a fruitful line of enquiry (Nijstad et al., 2010; Rietzschel et al., 2006). This effect will be reinforced if the initial breakdown of the problem into its component parts is conducted in a disciplined manner that demands a full exploration of the problem space.

The components of the problem that are subsequently identified and articulated as narrow problem frames will then be more likely to represent a broader scope of aspects that may be worthy of consideration. This approach is expanded upon below.

6.7.3 Beyond sub-problems: extracting principles and concepts

While there is a substantial body of evidence supporting the relative effectiveness of using sub-problems rather than the broad problem itself in generating creative solutions (Coskun et al., 2000; Dennis et al., 1996; Deuja et al., 2014; Ho, 2001; Liikkanen & Perttula, 2009), it is suggested that simply deconstructing broad problems to derive sub-problems may not yield an optimally effective set of problem frames.

Firstly, in order to deconstruct problems effectively, a purposeful strategy should be employed. Ho (2001) demonstrated that different techniques are used by experts and novices to deconstruct problems, in that experts use explicit strategies whereas novices do not, and the ad hoc approach employed by novices resulted in less efficient generation of ideas. Some of the particular differences in techniques noted in this study, were that experts start off considering a broader problem scope before deconstructing the problem, whereas novices start with defining the goals before taking a deep dive into the search for solutions.

It is suggested that without an explicit deconstruction strategy that is planned in advance, a default approach may well be to deconstruct the problem into the sub-problems that offer easily accessible solutions. Sub-problems identified in this unplanned manner may be subject to the same potential pitfalls as dealing with a broad problem frame, whereby reliance on the most readily available solutions may result in the resultant solution set pertaining to sub-problems which do not represent the key element to be addressed. As such, these sub-problems will be selected by default rather than conscious decision, resulting in solutions with a lower level of utility (Rietzschel et al., 2014).

It is further suggested than even when an explicit deconstruction method is applied, sub-problems derived may not serve as optimally effective springboards for creative problem solving when they are identified as independent entities. Consideration of relationships between sub-problems and their role within the broader problem frame may offer important insights when generating ideas for creative solutions. When problems or sub-problems are viewed in isolation, they may be subject to the risk of fixation, as "...limiting oneself to deep exploration of one or a few subcategories or interpretations of a problem can easily lead to fixation." (Rietzschel et al., 2006, p. 12.) Appreciation of relationships between sub-problems results in acknowledgement that a single sub-category or interpretation of the problem does not exist in isolation.

Another potential consequence of viewing sub-problems as free standing problems, is that elements of a problem in its specific context could be inadvertently incorporated in the solution. If the manifestation of the problem under specific circumstances is used in the definition of the problem, an element of the problem's manifestation in that specific domain may appear to the problem solver to be an intrinsic part of the problem, such that it persists into the solution. Ward and Kolomyts (2010) provide this example: "...anyone who has had to scroll down and then back up in reading a pdf version of a journal article in a format that mimics the two-column arrangement of its hard-copy counterpart knows that the copying of that exact format into electronic form is less than optimal from the point of view of the reader. ...Thus, a property of the old format (hard copy) was carried over to the new format (electronic) when it might have been more helpfully left behind." (Ward & Kolomyts, 2010, p.97) The tendency to represent concepts in terms of the specific instances of how they manifest has been found in novice designers, and leads to less creative solutions than when concepts are disentangled from the context (Kokotovich, 2008).

Yee (2019) refers to concepts being abstracted from our experience of reality by discerning similarities across exemplars, with the result that our understanding of concepts is dynamic, due to its being continually updated by experience. If conceptual knowledge is inherently dynamic, this provides another argument for developing conceptual mental models of a problem rather than models of directly experienced reality, since conceptual knowledge will inevitably be more fluid than knowledge derived from direct experience. Yee (2019) also asserts that abstraction to the conceptual level minimises idiosyncratic detail. In this way, higher levels of abstraction are more generalised and lower levels contain more detail.

It is therefore proposed that rather than simply dividing the problem into sub-problems, concepts or principles should be extracted to home in on core issues or ideas. This conceptual level of analysis is deemed necessary, based on the discussion above, to avoid presenting sub-problems only in the garb of their role in the overall problem. Such concepts should then be presented in a visual map, as given that structure plays an important role in creativity (see Section 5.2.2), a map containing an explicit representation of the concepts and relations between them supports the systematic rigour that is characteristic of cognitive persistence. Furthermore, awareness of the rules and parameters implicit in a structure can heighten sensitivity to the unexpected (Goldenberg et al., 1999).

The need to highlight critical concepts of the problem is clearly illustrated by the well-established prioritisation of conceptual combination, which relies on the identification of critical concepts that can be recombined in alternative formulations (Mumford, 2020).

It is therefore also suggested that the risk of limitations to cognitive flexibility associated with narrow problem frames may be addressed by extracting concepts from the problem, and using these concepts to frame new problems.

A Development of conceptual maps

Kokotovich (2008) proposes that the most effective visual map of a problem will be a more complex map representing a network of relationships, rather than simply connections between concepts. The suggested optimal map would be a networked, non-hierarchical mind map, which would include visual representations of bidirectional relationships, intermittent relationships and categorisation of concepts that can be grouped under particular themes. Kokotovich (2008) found in empirical studies that the greater the complexity of the representation, the more creative will be the solutions generated.

Oxman (2004) describes an approach to developing such conceptual maps by extrapolating from case based knowledge to describe the principles of the problem. As discussed in Section 6.5.3, case based knowledge does not provide the optimal fuel for creativity, but in practice, case based knowledge is often more accessible as it is the experience of specific instances that is likely to alert the business to the existence of a problem. It is argued, however, that such case based knowledge should only be used as the initial input to the concept map, after which relevant concepts and principles as well as the relationships between them must be distilled to enable the schematic knowledge that enables the fluidity of the model (Hunter, et al. 2006; Ward et al., 2004). (See discussion in Section 6.5.3 regarding the impact of different sources of knowledge.)

It is therefore suggested that using such case based knowledge as the input to the development of a concept map, which depicts schematic knowledge, can serve to develop a problem frame that offers 'the best of both worlds' in that it offers insights to which problem solvers can relate, while still providing the flexibility of working with concepts rather than concrete examples.

Oxman (2004) provides further justification for the proposed extra step of extracting concepts from sub-problems to develop such a visual concept map, by asserting that given that it is not simply the quantity of information that is important but rather how it is used, a problem frame that enables better use of information will be particularly useful. This assertion supports the proposition incorporated in the concentrated curiosity mode, that there will be a positive interaction effect between an interrogative information search and a 'networked mind map' or a representation of the problem that presents both the details and the relationships between them. (See Section 7.3 below for a discussion of the proposed interaction effect.)

The extraction of concepts from the broad problem statement enables and encourages an information search related to each of the concepts rather than the problem as a whole, which is likely to lead to a far richer, complex and more varied base of information, which will, in turn, be used to enrich the conceptual map. It is therefore suggested that an information search prompted by the full array of concepts underpinning the broader problem rather than a single problem frame is likely to result in a broader information search. Not surprisingly, Harms et al. (2018) found that a broader information search was more conducive to the generation of creative ideas.

6.8 Cognitive flexibility/ Triggering the flexibility pathway

Cognitive flexibility is well accepted as a key ingredient of creativity (Amabile & Pratt, 2016; Baas, De Dreu, & Nijstad, 2008; Chang & Shih, 2019) and the aim of this thesis is not to question its role but rather to explore how the flexibility pathway can be triggered.

Nijstad et al. (2010) describe cognitive flexibility quite broadly as the ability to switch between approaches or perspectives. While this may encapsulate the gist of the concept, the more comprehensive definition provided by Spiro et al. (1988) provides additional insights into the cognitive materials and methods that enable the exercising of this thinking style: "Cognitive flexibility involves the selective use of knowledge to adaptively fit the needs of understanding and decision making in a particular situation; the potential for maximally adaptive knowledge assembly depends on having available as full a representation of complexity to draw upon as possible." (Spiro et al., 1988, p.5) According to this definition, complex mental models provide the raw material for cognitive flexibility and to harness the value of the inherent multitude of factors and relationships between them, and overcome the reductionist thinking that precludes cognitive flexibility, the authors prescribe exploring alternative combinations of concepts within this intricate web.

It is suggested that attempting to increase cognitive flexibility by issuing instructions to consider alternative approaches or ways of viewing the problem, as might be suggested by the broad definition of cognitive flexibility, would be too vague to be of practical value. Moreover, an individual's success in considering the problem from multiple perspectives will depend on inherent cognitive flexibility, making this instruction tautological. The question which then emerges is how to maintain cognitive flexibility and overcome the natural tendency to settle on the first solution that works, rather than continue to search for alternatives (Ward, 1994). A number of researchers have explored this question (Dane, 2010; Locke et al., 2008; Miron-Spektor, Gino & Argote, 2011), and on examining their suggested approaches, it is interesting to note that the active stimulation of doubt is incorporated in all.

6.9 Actively harnessing doubt

In his argument for the positive role of domain expertise, Baer (2015) makes the interesting comment that it is not the domain specific expertise itself that is responsible for a negative relationship with creativity, but rather a consequent lack of humility. But a lack of humility is not a natural consequence of domain expertise, as demonstrated in findings that expert teachers have less confidence in the completeness of their knowledge than novice teachers (Schempp et al., 1998). (See Section 6.5.2) Sutton and Hargadon (1996) assert, in fact, that doubt is a component of wisdom, which suggests that in the absence of doubt, specific knowledge of a particular domain will be confined to the strict parameters of that domain, with limited abilities to consider the relevant implications or insights as to how to apply that knowledge. Such practical applications of knowledge are intrinsic to wisdom, as suggested by Pasupathi, Staudinger and Baltes (2001).

The positive role of doubt and humility in creativity has been endorsed by a number of other authors, such as Srikantia and Pasmore (1996) who assert that doubt is not only useful but essential for organisational learning and innovation. Mumford et al. (2020) also posit that over confidence in the existing understanding of the problem is one of the most prevalent reasons for failure in creative problem solving.

Of course it is especially challenging to actively encourage the overt expression of doubt in business today, where 'not knowing' is seen a state to be quickly overcome. This has a wide variety of implications, such as that expressed by Basadur and Basadur (2011) who argue that skills in problem finding and construction are underdeveloped due to the overt emphasis on problem solving and solution finding.

The aversion to doubt also influences the information search process itself, as researchers are "...rewarded for knowing and have been encouraged to show that we know and that we know quickly" (Locke et al., 2008, p.912). In their thought provoking article, these authors describe the value of doubt in supporting cognitive flexibility and generating ideas and therefore propose that doubt should be actively cultivated. They describe how the "irritation of doubt" (Locke et al., 2008, p.908) provokes the development of new solutions and ideas as it not only enables the required open mindedness but also creates the impetus to generate new ideas. The clear benefits of doubt, especially when seen in the context of the inherent propensity to dispense with, rather than embrace doubt, provides a further argument for the development of a practical approach that can be used to nurture doubt.

6.9.1 *Approaches used to stimulate doubt to support cognitive flexibility*

One approach that has been used to maintain cognitive flexibility includes priming research subjects with paradoxes to encourage participants to juxtapose disparate or contradictory elements in their idea generation (Miron-Spektor et al., 2011).

This approach involves intentionally introducing internal conflict to counter fixed mindsets and provoke more creative responses. Findings of this research were that participants were indeed able to generate more creative ideas, in part due to their increased exploration.

In the explication of his theory of cognitive entrenchment, Dane (2010) concludes that experts can also be flexible and proposes two approaches that can facilitate cognitive flexibility, especially in the context of domain expertise, which is seen as carrying the associated threat of cognitive entrenchment, or fixation. The first approach proposed as a mediator in the relationship between expertise and cognitive entrenchment, is engagement in a 'dynamic' environment in the area of expertise. The second is engagement in tasks outside of the area of expertise. While theoretically, these suggestions are defensible and may support the nurturing of a more creative climate in the longer term, there are practical concerns regarding their implementation, especially when creativity needs to be facilitated to solve a particular problem within a limited time frame. Under such circumstances, temporarily immersing individuals in a dynamic environment and redirecting their efforts to another field may be not only onerous to implement, but may also meet with limited, or at best, unpredictable success. Both approaches, however, are underpinned by the active stimulation of doubt.

One of the more practically applicable approaches explored by Locke et al. (2008), is the disruption of order. Order allows for a predictable and therefore comfortable sequence of thoughts, which will enable default thinking. By disrupting order, unexpected thoughts are invited in, and more deliberate, conscious processing is demanded.

6.9.2 The proposed use of an interrogative information search to stimulate doubt

It is proposed that an interrogative information search, which focuses on the questioning process, would also involve adopting a position of doubt.

High levels of confidence in the information one already has decreases the motivation to explore to gain a richer understanding (De Dreu, Nijstad, & Knippenberg, 2008). By actively focusing on and seeking out questions, the individual is consistently highlighting gaps in their knowledge, such that such complacency is avoided.

The role of the interrogative information search is therefore not only to search for and find alternative information and perspectives, as described in Section 6.6 above, but also to keep holding a place for doubt. The spiral depicted in Figure 3 portrays the lack of an end point, illustrating the view that there is no point at which the problem solver can claim to have arrived at a full understanding of all possible perspectives of and insights into the problem. This implies that an attitude of humility and doubt

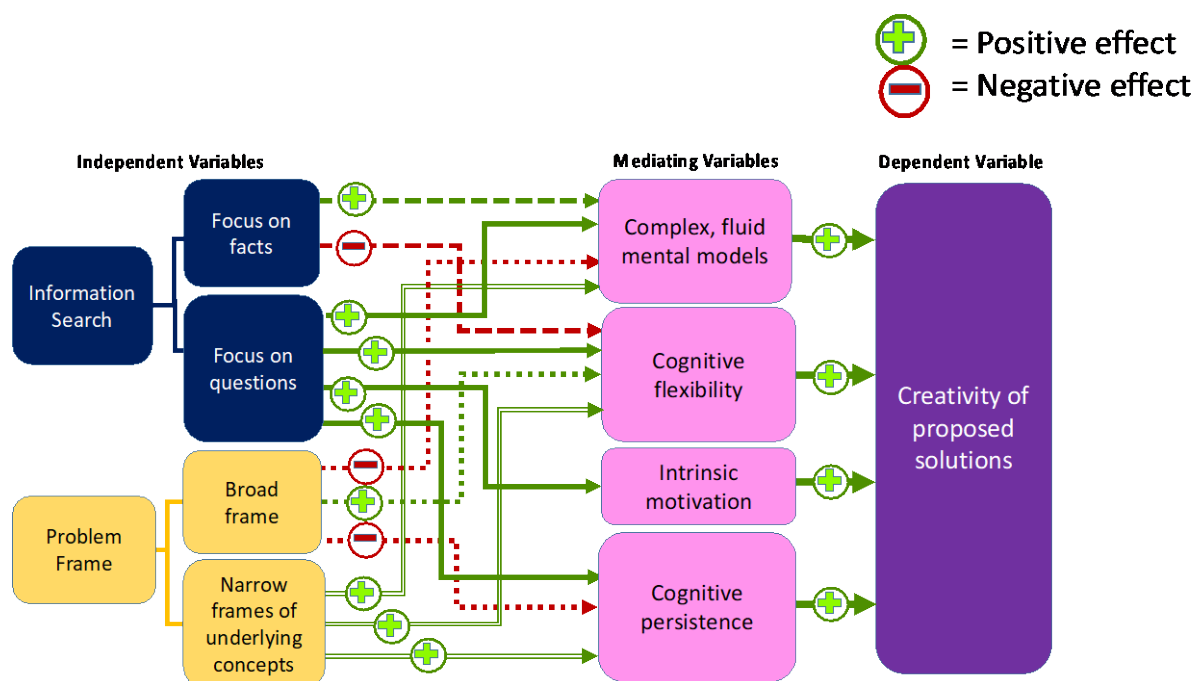
about one's current perspective must be maintained.

7 PROPOSED RELATIVE ADVANTAGES OF THE CONCENTRATED CURIOSITY MODEL

While the detailed cause and effect relationships proposed in the concentrated curiosity model and the rationale and research findings supporting it are described in Section 6 above, this section contains a description of the relative advantages that are implied by the specified approaches. Specifically, the proposed advantages of an interrogative as opposed to a factual information search and a series of narrow versus a broad problem frame are argued here. This gives rise to the hypotheses which enable empirical testing of the concentrated curiosity model in an experimental study in Paper 2.

Figure 5

Relative advantages of proposed approach



7.1 Proposed advantages of an interrogative information search over a factual information search

Key principles found in the literature, which have informed the propositions described in Figure 5 above are provided in Table 2 below.

Table 2

Propositions regarding relative advantages of interrogative information search

Finding from the literature	Related proposition
1. Domain expertise can be enhanced by a dedicated information search, given that the purpose of an information search is to build knowledge and knowledge can be equated with expertise (Weisberg, 2006). Questioning facilitates the development of more fluid mental models (Rea-Ramirez, Nunez-Oviedo, & Clement, 2009).	Both a factual information search and an interrogative information search are assumed to build the complex mental models associated with domain expertise. It is proposed that an interrogative information search will ensure that the model is more fluid and dynamic.
2. There is a trade-off between domain expertise and cognitive flexibility beyond a certain point of domain expertise (Simonton, 1983).	A factual information search will have a positive relationship with domain expertise, but subsequent familiarity with the facts may have a neutral to negative relationship with cognitive flexibility.
3. A key driver of creativity is the ability to overcome the tendency to follow the path of least resistance (Ward, 1994) and maintain cognitive flexibility (Dane, 2010; Miron-Spektor & Beenen, 2015; Rietzschel et al., 2006)	While domain expertise is valuable, the approach to the information search should be to build a complex mental model that is also fluid, thus simultaneously promoting cognitive flexibility.
4. Research on the role of learning goals has indicated that those who specifically set out with the goal of learning, as opposed to a goal of achieving a certain performance outcome, demonstrate a higher level of cognitive flexibility in creative tasks (Miron-Spektor & Beenen, 2015).	An interrogative information search, which focuses on the questioning process and incorporates the cycle of questioning, answering questions and generating new questions, is better able to maintain open mindedness and cognitive flexibility than one focussed on searching for facts.
5. Doubt and the purposeful activation of doubt has been shown to maintain cognitive flexibility consistent with creativity (Locke et al., 2008; Dane, 2010).	It is proposed that an interrogative information search will activate levels of doubt and uncertainty that would not result from a factual information search, due to its inherent focus on highlighting gaps in knowledge.

Finding from the literature	Related proposition
6. Research to define the problem is likely to enhance intrinsic interest and motivation in the problem, as this increases the likelihood that the problem frame will align with the individual's interests (Amabile, 1996a; Runco & Nemiro, 1994).	If in the course of the information search, the individual is focusing on generating their own questions, rather than restating the facts they encounter, it is hypothesized that this might enhance their engagement with the problem, thereby enhancing their intrinsic motivation.
7. Cognitive persistence has been described in the dual pathway model as an approach in which the individual engages in a deep exploration of the subject matter (Nijstad et al., 2010).	Deep exploration of the problem area will be facilitated by an active search for relevant questions. The active nature and level of engagement required by an interrogative information search may in fact facilitate deeper exploration of the subject matter than a factual information search which requires noting of facts that emerge.

Based on the preceding argument, the proposed concentrated curiosity model incorporates the proposition that an interrogative information search will be more positively associated with creative solutions due to its positive relationships with not only the mediating variable of complex, fluid mental models, but also cognitive flexibility, intrinsic motivation, and cognitive persistence. Therefore, hypothesis one is formulated as follows:

H1: An information search designed to encourage questioning is more positively associated with creative solutions than an information search designed to identify facts

7.2 Proposed advantages of using sub-frames of underlying concepts over a broad problem frame

In considering the role that the problem frame plays in creative thinking, it is not only the end result of the nature of the problem frame that needs to be considered, but also the cognitive processes that are required to formulate the particular problem frame.

Key findings from the literature that support the proposition that problems should be framed in narrowly defined sub-frames of the underlying concepts and principles, rather than adopting a broad problem frame, are laid out in Table 3 below.

Table 3

Propositions regarding relative advantages of sub frames of underlying concepts

Finding from the literature	Related proposition
1. Broad problem frames are associated with greater cognitive flexibility due to the ease of switching attention to different aspects of the problem within the scope of the problem space (Friedman et al., 2003; Shalley et al., 2015).	A broad problem frame will support cognitive flexibility.
2. While there is a risk of lowered cognitive flexibility associated with narrow problem frames (Rietzschel et al., 2006) it is proposed that the initial identification of underlying concepts within the problem (Hunter et al., 2006; Mumford, 2020; Ward et al., 2004), and using these to form sub-problems, as well as focusing on sub-frames consecutively (Coskun et al., 2000; Dennis et al., 1996) will promote cognitive flexibility.	Focussing sequentially on narrow problem frames based on underlying concepts within the problem will enhance cognitive flexibility.
3. A single, broad problem frame may lead to grouping elements that might be disassembled, thereby building mental models that are less complex and fluid (Ward & Kolomyts, 2010).	Broad problem frames are negatively associated with complex, fluid mental models.
4. Sequential focus on sub-problems ultimately facilitates focus on a broader range of issues than when focusing on a single broad problem frame (Dennis, Valacich, Connolly, & Wynne, 1996) and identification of underlying concepts feeds into a more complex, fluid mental model (Hester et al., 2012).	Problem framing by deconstructing the problem into sub-frames of underlying concepts will build more complex, fluid mental models.
5. A broad problem frame will demand less cognitive persistence, as a broad frame allows for a greater range of available solutions. A narrow frame, on the other hand, will demand more cognitive persistence, related to the deeper search required to generate solutions. (Dreisbach & Goschke 2004; Koch et al., 2008; Nijstad et al., 2010; Rietzschel et al., 2014).	Broad problem frames demand less cognitive persistence whereas narrow problem frames demand and will therefore lead to higher levels of cognitive persistence.

The propositions described in the table above give rise to the second hypothesis:

H2: A problem frame comprising sub-problems addressing underlying concepts is more positively associated with creative solutions than a single problem frame with a broad focus

7.3 Interaction effect

In the concentrated curiosity model, it is the combination of the sequential sub-problem statements addressing underlying concepts and an interrogative information search that is proposed to have the most positive relationship with the creativity of resultant solutions generated, as it is argued that these two approaches are mutually reinforcing. No literature could be sourced to support this argument, as the suggested approaches to both the information search and problem framing have been formulated in this thesis, however the reasoning underlying this proposed interaction effect is outlined below.

It is suggested that the interaction effect is due to the compensatory effects of stimulating both the flexibility and persistence paths simultaneously, which enables the problem solver to capitalize on the advantages of both while managing the risks of each. Given that the interrogative information search is designed to spark curiosity and more extensive exploration of the problem, there is an associated risk of loss of focus if the exploration leads the problem solver in directions that they may find interesting, but may be less pertinent to the particular problem. This may have the result of generating solutions that may be more original but of less practical relevance. It is suggested that the use of successive narrow problem frames, each of which center on a key concept of the problem, will maintain the required level of focus, such that exploration is directed to relevant insights.

There are risks associated with using narrow problem frames – most particularly in the form of limited cognitive flexibility and the associated ‘tunnel vision’ that could limit the problem solver’s ability to make connections and generate more original solutions. The interrogative information search is designed to extend the problem solvers thinking within this problem space however, demanding that the problem solver ‘digs deep’, as deep exploration has been shown to produce more creative solutions (Rietzschel et al., 2006)

This argument is encapsulated in the third hypothesis:

H3: There is a positive interaction effect between the sequential focus on sub-problems addressing underlying concepts and an interrogative information search on the creativity of solutions

7.4 Relationship between research objectives, research questions, hypotheses and propositions

The consistency table below includes the research objectives and questions that pertain to the development of theoretical model and the related hypotheses and propositions based on the discussion above.

Table 4*Consistency table*

Research objectives	Research questions	Hypotheses and propositions
1 To explore the relative effectiveness of different approaches to problem framing	1. Is a broad problem frame or a series of sub-problem frames focussed on underlying concepts more positively associated with the creativity of ideas generated?	A series of sub-problem frames focussed on underlying concepts is more positively associated with creative solutions than a problem frame with a broad focus.
2. To explore the relative effectiveness of different approaches to the information search	2. Is a fact focused or a question focused information search more positively associated with the creativity of ideas generated?	An information search designed to focus on the questioning process is more positively associated with creative solutions than an information search designed to identify facts.
3. To explore the effect of the combination of different approaches to problem framing and the information search	3. Is there a significant interaction effect between the breadth of scope of the problem frame and the mode of information search?	There is a positive interaction effect between a series of sub-problem frames focussed on underlying concepts and an interrogative information search.
4. To explore whether the combination of different approaches to the information search and problem framing have a different impact on the mediating mechanisms that explain the main effects, specifically complexity of mental models, cognitive flexibility, intrinsic motivation and cognitive persistence	4. If the above holds, what are the explanatory mediating mechanisms that explain the main effects, specifically complex, fluid mental models, cognitive flexibility, intrinsic motivation and cognitive persistence?	4.1 An interrogative information search will build a more complex, fluid mental model of the problem than a factual information search. This effect will be strengthened by the simultaneous utilisation of a series of sub-problem frames focussed on underlying concepts. 4.2 An interrogative information search will be more strongly related to cognitive flexibility than a factual information search.

4.3 A series of sub-problem frames focussed on underlying concepts will have a stronger relationship with cognitive flexibility than a broad problem frame, and this effect will be strengthened by the simultaneous implementation of an interrogative information search.

4.4 An interrogative information search will support a higher level of intrinsic motivation than a factual information search.

4.5 A series of sub-problem frames focussed on underlying concepts will have a positive relationship with cognitive persistence, the effect of which will be strengthened by the simultaneous implementation of an interrogative information search.

8 GAPS IN THE LITERATURE

Much of the research measuring creativity under different conditions has been conducted in laboratory settings based on tasks that are not grounded in real world problems in general or business problems in particular. To illustrate this point, a commonly used creativity problem posed in research studies is to ask participants to make a drawing of an alien (Kray, Galinsky, & Wong, 2006; Rietzschel, De Dreu, & Nijstad, 2007; Ward et al., 2004). This raises some questions as to the external validity of these studies.

While the role of structure and constraints in the creative problem solving process has been subject to some scrutiny in the literature, findings are inconclusive – especially around approaches to mitigate against the potential negative effects of imposed structure and constraints while harnessing the potential benefits. This is particularly true for the role of domain specificity and the associated complexity of mental models, which, by definition, requires a constrained focus.

Sagiv et al. (2010) caution that while the findings of the current research support the contention that constraining tasks should lead to higher creativity, they do not claim that any structure at all is beneficial, as some types of restriction may have detrimental effects. They go on to recommend future lines of study, which are pursued in this thesis, namely, that “future studies could investigate the usefulness of other types of restrictions and delineate the boundary conditions for externally imposed structure—which constraints are likely to boost creativity and which are ineffective, or may even decrease it.” (Sagiv et al., 2010, p.18)

Reiter-Palmon and Robinson (2009) agree that research is needed to determine whether constraints limit or increase originality, as mixed findings could result from methodological differences, or from the type of restrictions imposed. Although the impact of a variety of constraints on creativity have been considered theoretically, they say, there is limited empirical research in this area. They also suggest it is possible that attention to different combinations of elements of the problem representation may result in different outcomes, but that as yet, we don’t understand these effects.

Notwithstanding the exploration of approaches such as the use of paradox and conflict (Miron-Spektor et al., 2011) and the active stimulation of doubt (Locke et al., 2008) to determine their impact on avoiding the fixation that can result from domain expertise, there are gaps in the research literature regarding the development and testing of practical, replicable methodologies to build domain expertise while guarding against the potential negative impact of domain expertise on creativity. One of the objectives of this thesis is to address this gap.

As mentioned above, only minimal research has been conducted on the role of the information search within the creative problem solving process, with even less attention being paid to the relative effectiveness of alternative approaches to the information search.

While different disruptive approaches are discussed in their article, Locke et al. (2008) have identified gaps in the literature regarding approaches to maintain humility and openness in the research process and conclude their article with a call to the community to develop such research methodologies. An aim of this thesis is to respond to this call by structuring the information search in such a way as to encourage open mindedness and avoid settling on fixed positions.

8.1 Limitations

While the literature review has aimed to identify and incorporate all salient research, it is unlikely that the full spectrum of literature has been included. Therefore rather than attempting to cover a broad scope of literature on creative problem solving, the aim has been to review the literature pertinent to the above discussion and related issues in depth.

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As such, this literature review has not incorporated literature on person centred approaches such as individual differences in approaches to creative problem solving, mindsets, perceptions, attitudes or skills. Studies of creative products which highlight characteristics of creative outputs have also not been included. Literature on environmental factors such as the role of leadership, culture and climate has also not been covered. It would be useful for future studies to consider incorporating a review of such literature in considering the potential impact of such variables in the application of this theory.

As contextual factors and individual differences have not been considered in the development of this theory, the implicit assumption is that the propositions in this theory would hold true regardless of individual or environmental variables. It should be noted that such factors may well merit consideration in future studies.

PAPER 2: EXPERIMENT TO TEST THEORETICAL MODEL

9 INTRODUCTION TO EXPERIMENTAL RESEARCH METHODOLOGY

In Paper 2 of this thesis, the concentrated curiosity model was tested in an experiment designed to test the hypotheses underpinning the model, namely:

H1: An information search designed to encourage questioning is more positively associated with creative solutions than an information search designed to identify facts

H2: A problem frame comprising sub-problems addressing underlying concepts is more positively associated with creative solutions than a single problem frame with a broad focus

H3: There is a positive interaction effect between the sequential focus on sub problems addressing underlying concepts and an interrogative information search on the creativity of solutions

The aim of this study was therefore to assess the differences in the effect size of the two independent variables of problem frame and information search on the dependent variable of creativity. The experiment was designed and conducted to test for significant differences in the dependent variable under the alternative conditions which were manipulated in the experimental conditions.

10 METHODOLOGY

In the experimental design, four groups of employees were required to identify creative solutions to the problem of how to enhance the organisation's app to optimise the client experience. This research was conducted in an organisation in the financial services industry for which creativity is a priority.

For the purpose of this experiment, analysis was conducted at the level of the individual. There are a number of advantages of using individual rather than group scores of creativity. Firstly, comparing each individual's score pre and post application of the experimental condition minimizes sampling bias. Secondly, interactions between group members will not impact on results. This is a key factor to be considered in the development of a replicable normative framework, as group dynamics may vary widely and cannot be easily managed.

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Thirdly, the design controls for individual differences in aptitude, as each individual will have his or her own score under the experimental condition compared with their own baseline score. A further justification for taking measurements at the level of the individual, is the assertion by Runco and Nemiro (1994) that problem construction is an individualistic activity.

To establish baseline measures of creativity, individuals in all groups were asked to propose creative solutions to enhance the customer experience of the app. An ideation technique was developed for the purpose of this experiment, as no existing ideation technique could be found that was considered suitable for this task. This technique, called DREAM TEAM, (see Figure 17 in Paper 3) was taught to the each group, to ensure that all individuals used the same approach to generate creative solutions. The creativity of proposed solutions was judged using independent judges and the consensual assessment technique (Amabile,1982). In assessing the creativity of solutions generated, the two criteria of originality and utility were applied, as per the definition of creativity being the production of novel and useful ideas (Barron,1955; Runco & Jaeger, 2012). A baseline creativity score was calculated for each individual using the consensual assessment technique (Amabile, 1982). (See Section 10.2.3)

Participants in the experiment were randomly assigned to one of four groups, with each group being assigned to one of four experimental conditions, these being as follows:

Group 1: Broad problem frame and factual information search: This group, hereafter referred to as the 'Broad Factual' group, used a problem frame with a broad focus and an information search aimed at identifying relevant facts.

Group 2: Broad problem frame and interrogative information search: This group, hereafter referred to as the 'Broad Interrogative' group, used a problem frame with a broad focus and an information search aimed at generating relevant questions.

Group 3: Narrow problem frame and factual information search: This group, hereafter referred to as the 'Narrow Factual', group used a problem frame with a narrow focus and an information search aimed at identifying relevant facts.

Group 4: Narrow problem frame and interrogative information search: This group, hereafter referred to as the 'Narrow Interrogative' group, used a problem frame with a narrow focus and an information search aimed at generating relevant questions.

There were eleven participants in each of the four groups.

To establish baseline measures of creativity, individuals were not instructed to adopt a particular approach to problem construction, but were all asked to generate creative solutions using the DREAM TEAM, such that they were all taught and all used the same ideation technique.

Individuals in all groups were asked to work on the same problem of how to enhance their app, and to come up with creative solutions to address this. After they had submitted their first solutions, research participants were then given instructions as to the approach they should adopt to problem construction, according to their assigned experimental condition. Participants were then asked to generate creative solutions to the problem using the same ideation technique they used when generating their first solution.

Each individual therefore submitted two solutions, namely a baseline solutions and a solution generated under experimental conditions. Creativity of all solutions was measured using consensual assessment (See Section 10.2.3).

The creativity scores obtained before and after application of the alternative problem construction approaches were compared across the four experimental conditions assigned to the groups. Data was analysed to compare pre and post experimental scores for each individual, with the aim of identifying which, if any, condition was associated with the greatest difference between the baseline creativity score and the experimental creativity score.

In addition to submitting the solutions they considered most creative, participants were also asked to submit the questions they had generated and the facts they had compiled in the course of the information search they conducted. They were also asked to complete a self-assessment questionnaire based on their perception of the extent to which they had experienced shifts in the states proposed as mediators (see Section 10.2.2).

10.1 Case site and sample

The study was conducted within a multi-national business in the financial services industry recognized in the South African business community as an exemplar, given their commitment to innovation. As innovation and the management of the client experience are strategic priorities for this organisation across their international markets, the middle and senior managers and specialists from whom the sample was drawn, are individuals from whom a high level of creativity is expected. Participants were based in South Africa and the United States, which was enabled by the fact that the study was conducted in online meetings between the researcher and participants.

The fact that innovation is already a prerequisite for this organisation, enables the study to test how the application of this particular approach to creative problem solving might extend the creative performance of a population for which creativity is already a familiar value and performance criterion.

While the research was conducted in a controlled setting within this organisation, similar to a laboratory setting, there are aspects of a field study incorporated in that the research was conducted in an online meeting with colleagues – a format with which they are familiar - using their real work challenges as the context of the creative ideas to be generated. This context supports the generalisability of the research.

The selection of this case site and population of middle to senior managers and specialists did, however, imply challenges in recruiting participants, as all were required to offer two and a half hours of their time to participate in the experiment. While individuals in this target population were informed that the study would involve trying to develop creative solutions to a problem that was important to the business, it was naturally not easy for them to commit to setting aside the requisite two and a half hours from their demanding jobs.

10.1.1 Sampling method and sampling frame

The population from which the sample was drawn comprised middle to senior managers and specialists within the company. Emails were sent to the population inviting them to participate in the study, providing them with information as to its purpose and assuring them of their confidentiality.

While a voluntary sample may, in principle, be subject to bias, this limitation is mitigated by the approach to analysis, whereby each individual's creativity score obtained after implementation of the experimental condition was compared with their own baseline score obtained prior to application of the different conditions. Absolute scores are therefore not relevant to the study, such that differences in creative ability did not impact on the statistics. The fact that the voluntary sample may contain biases in selection should therefore not have a material impact on the data or the ability to generalize the findings.

A control group was not required for this study, as when using the repeated measures ANOVA and MANOVA for analysis, each group serves as its own control (Girden, 1992).

The final sample comprised 44 participants who were randomly assigned to one of four groups such that there were eleven participants in each group. While random sampling would not have been practical for this study, the random assignment enabled the experiment to conform to the requirements of a true experiment (Gribbons & Herman, 1996).

10.2 Definitions and measurements of variables

Hypotheses are restated here such that definitions of variables can be clearly linked to key constructs in the hypotheses.

H1: An information search designed to encourage questioning is more positively associated with creative solutions than an information search designed to identify facts

H2: A problem frame comprising sub-problems addressing underlying concepts is more positively associated with creative solutions than a single problem frame with a broad focus

H3: There is a positive interaction effect between the sequential focus on sub problems addressing underlying concepts and an interrogative information search on the creativity of solutions

10.2.1 Independent variables

The two independent variables manipulated under the four experimental conditions were:

Nature of information search, which is also a binary variable for which there are two treatments, namely factual or interrogative. A factual information search is designed to identify facts and an interrogative information search is designed to encourage questioning. The two treatments are built into the instructions to participants.

Breadth of problem frame, which is essentially a binary variable for which the two treatments are a broad scope or a narrow scope. A broad scope pertains to a single problem frame with a broad focus and a narrow scope pertains to sub-problems of the problem frame that address underlying concepts. The two treatments for the problem frame are built into the instructions to participants.

The Powerpoint slides of instructions to participants are available on request.

10.2.2 Dependent variables

Dependent variables included *creativity* of solutions, as well as the components of creativity, namely *originality* and *utility*.

Creativity, the main dependent variable, is expressed as the creativity score for the solutions proposed by individual participants. Consensual assessment, an approach referred to in the literature as the 'gold standard' of measuring creativity (Baer & McKool, 2009; Carson, 2006; Hennessey, Amabile, & Mueller, 2011) was used to measure the creativity of ideas generated.

This technique is widely employed across different disciplines within creativity research and has been well validated. (Baer, Kaufman, & Gentile, 2004; Baer & McKool, 2009; Hennessey et al., 2011). It does not depend on any particular theory of creativity and has been shown to be free of racial or gender bias (Baer & McKool, 2009). This technique uses expert judgements of the solution creativity, provided by judges on a five-point Likert-type scale as discussed below.

Consensual assessment typically employs only one global, subjective assessment of the single dimension of creativity (Amabile, 1982). This differs from traditional measurement techniques in which sub-dimensions are pre-defined and then rated. Amabile (2018) argues that these tests depend on a number of sub-categories of creativity that have been defined by the researcher, and that relying more on the subjective ratings of overall creativity by judges has yielded both more valid and more reliable results.

In this study, however, two different scores were required from each judge on perceptions of solution *originality* and *utility*, given that the definition of creativity involves and requires both of these dimensions (Barron, 1955; Runco & Jaeger, 2012) and that either construct on its own would be inadequate in describing the desired outcome of an effective creative solution. This approach of using two constructs has been used to good effect in measuring creativity, and furthermore enabled additional analysis of the two underlying constructs of originality and utility as dependent variables (Reiter-Palmon et al., 1997; Harrington, Block, & Block, 1983).

A Measurement of dependent variables

Three independent judges with knowledge of the domain assessed the proposed solutions using the criteria of originality and utility. Judge 1 was the Head of Product Development for the company, judge 2 was the Head of Strategic Programs and judge 3 was the Head of Member Experience. While judges 1 and 2 were at the same level of senior management, judge 3 was at a more junior level of management and reported to judge 2.

Each judge selected a rating on a five-point Likert scale. For the criterion of novelty, the scale used was 1 = not at all original, 2 = slightly original, 3 = moderately original, 4 = very original, 5 = extremely original. For the criterion of utility, the scale was 1 = not at all useful, 2 = slightly useful, 3 = moderately useful, 4 = very useful, 5 = extremely useful. By using Qualtrics for scoring purposes, a slider was incorporated to enable scores of both utility and novelty to be continuous variables.

To avoid introducing bias in assessment, judges were not aware of the purpose of their assessments, nor were they aware of the identity of the participants whose ideas were being assessed, nor the conditions to which they had been assigned.

Furthermore, other than receiving high level instructions for conducting their assessments, conveyed in an email and one online meeting, judges were not trained and each judge conducted their assessments independently, without conferring with each other (Baer & McKool, 2009; Hennessey et al., 2011).

Separate scores for originality and utility were calculated as the average of the judges' ratings for each of these variables. Creativity scores for each participant's proposed solution were calculated by multiplying together scores for each of the two underlying criteria (Harrington et al., 1983; Mumford & Gustafson, 1988; Reiter-Palmon et al., 1997).

B Assessments of reliability of dependent variables

While Cohen's Kappa was originally considered to test inter-rater reliability, it was decided that this was not an appropriate approach as this is primarily used to assess the reliability of categorical and nominal variables and tests for inter-rater agreement rather than reliability (Tinsley & Weiss, 2000). While inter-rater agreement requires that judges make exactly the same judgements, tests of inter-rater reliability "... represents the degree to which judges' ratings are proportional when expressed as deviations from their means." (Tinsley & Weiss, 2000 p.98). Therefore tests of inter-rater reliability and agreement can be used interchangeably when dealing with nominal variables but not ordinal variables.

Given the subjective nature of the ratings as well as the resultant unequal standard deviations in ratings, rankings of creativity scores were used in the testing of inter-rater reliability as the ranking of individual creativity scores was determined to be more pertinent than the actual scores assigned. Inter-rater reliability between the judges' scores was therefore tested using Spearman's rho and Kendall's tau after ranking the scores. From these analyses it was found that, when looking at inter-rater reliability for both baseline and experimental creativity scores, scores assigned by the first two judges were significantly correlated at the .05 level, but scores assigned by judge 3 were not significantly correlated with the scores of judges 1 and 2. Consequently, creativity scores used in the subsequent analyses were based only on ratings by the first two judges amongst whom inter-rater reliability was established, and ratings by judge 3 were excluded.

10.2.3 Mediating variables

The literature review that informed the development of the concentrated curiosity model led to the identification of four mediating variables (see Section 6 in Paper 1), namely:

Complexity of mental model, which refers to the number of concepts in a mental model and the number of linkages between concepts (Hester et al., 2012)

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Cognitive flexibility which refers to the ability to adapt one's perspective or cognitive strategy in response to changes in the situation or environment (Gabrys, Tabri, Anisman, & Matheson, 2018),

Intrinsic motivation, which pertains to the engagement with the task based on enjoyment of, and interest in the task itself (Cerasoli, Nicklin, & Ford, 2014), and

Cognitive persistence, which can be defined as "the degree of sustained and focused task-directed cognitive effort" (Nijstad, De Dreu, Rietzschel, & Baas, 2010, p.42).

Measures of the mediating variables were derived from completion of questionnaires which were developed and validated prior to administering them to participants. This development process is described below.

A Development of measures of mediating variables

For the purposes of this study, measures of these mediating variables needed to be based on each participant's self-perception of changes in their state, as a result of implementing the particular approach to problem construction they used, which differed according to the experimental condition to which they were assigned.

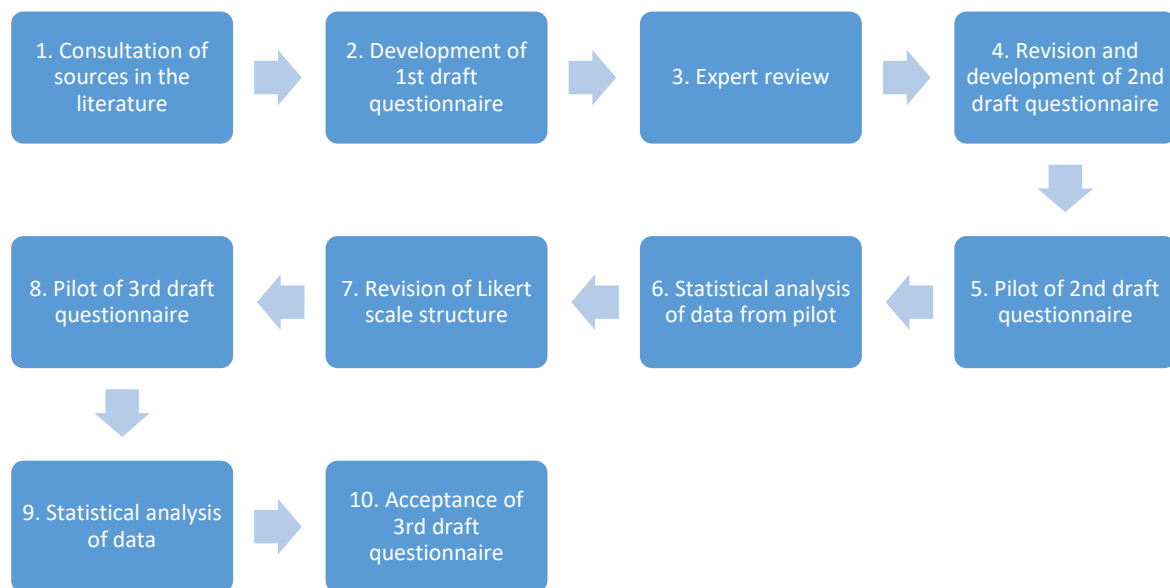
A review of the literature did not yield scales that could be used in this experiment, as while some instruments do exist in the literature to measure these variables, they are predominantly measures of traits as opposed to states and do not address changes in state. An instrument therefore had to be developed to measure self-perceptions of changes in participants' complexity of mental models, cognitive flexibility, intrinsic motivation and cognitive persistence after using the particular approach to problem construction they were instructed to employ.

B Process adopted to develop, validate and test reliability of measures of mediating variables

The development of the questionnaire proceeded as shown in the flow diagram below:

Figure 6

Flow diagram depicting stages in development of questionnaire on mediating variables



Sources were consulted from the literature for cognitive flexibility (Dennis & Vander Wal, 2010; Gabrys et al., 2018; Martin & Rubin, 1995; Vriezeolk, van Lankveld, Eijsbouts, van Helmond, Geenen, & van den Ende, 2012), complexity of mental models (Hester, et al., 2012; Kokotovich, 2007; Malaycha & Maier, 2017; Ward & Kolomyts, 2010), intrinsic motivation (Nakamura et al., 2019; Prabhu, Sutton & Sauser, 2008; Ryan & Deci, 2000) and cognitive persistence (Doherty-Bigara & Gilmore, 2015; Dreisbach & Goschke, 2004; Nijstad et al., 2010; Teubner-Rhodes, Vaden, Dubno, & Eckert, 2017).

These sources informed the development of the first draft questionnaire, which included twenty statements comprised of five positive statements related to each of the four mediating variables. The response format required the participant to compare their second attempt at generating ideas, under experimental conditions, with their first experience, under baseline conditions.

After the development of the first draft questionnaire, to assess the face validity of the questionnaire, three expert reviewers were consulted. These included Professor Karen Milner, Dr Ronel Duchon, and Dr Amelia Richards, who specialize in organisational psychology, counselling psychology and market research respectively.

Professor Milner (PhD) is an associate professor in Organisational Psychology at the University of the Witwatersrand and has over 20 years' experience in teaching and research in this field.

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Her research is predominantly quantitative and she has extensive experience in scale development with some expertise in the specific content area covered in this instrument. Professor Milner has published extensively in the field of health and wellbeing (including mental health) in the work-place in both local and international journals and has spoken at many local and international conferences on this topic.

Dr Petronella Maria Duchen has 30 years of experience as a senior Counselling Psychologist. She has a B.Sc (Mathematical Sciences), National Higher Education Diploma, B.Sc (Hon) and MA (Psychology) (cum laude) as well as a D.Litt. et Phil degree focusing on psychological test development, construction and validation. Dr Duchen provides on-going professional training and supervision to mental health professionals and mediators. She is the co-author of books and papers that have been presented at both local and international conferences.

Dr Amelia Richards has been working in research for over 22 years with an emphasis on market and advertising research. She has held the position of Service Line Director for Ipsos South Africa for the last 2 years and specialises in conceptualising, designing and executing research. Her prior experience includes serving as Account Director for Ask Afrika, and prior to that as Account Manager for Millward Brown. Dr Richards has a PhD in Psychology from the University of Pretoria.

Once the input of these expert reviewers had been used to refine the questionnaire, a pilot study amongst nine participants was conducted. Calculation of standard deviations of responses indicated that the range of responses could be extended. The response format was therefore extended from a five-point Likert scale to a seven-point Likert scale. After this questionnaire with the revised response format was piloted again with another 12 respondents, standard deviations were considered acceptable, and this revised version of the questionnaire was accepted as the final version. Results of the analysis are shown in Table 5 below.

Table 5

Standard deviations of piloted versions of the mediators questionnaire

Mediators:	Complexity of mental models	Cognitive flexibility	Intrinsic motivation	Cognitive persistence
5 point Likert scale	.40	.48	.61	.51
7 point Likert scale	.54	.76	.67	1.00

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An analysis of inter-item reliability was also conducted on each scale, the results of which follow in Table 6 below.

Table 6

Inter-item reliability of scales, as indicated by Chronbach's alpha's

Mediators:	Complexity of mental models	Cognitive flexibility	Intrinsic motivation	Cognitive persistence
Chronbach's alpha	.85	.77	.84	.82

Mediating variables have acceptable internal consistency, as indicated by the results of the Cronbach's alpha analysis, as these are all greater than .7.

C Final questionnaire to measure mediating variables

The final questionnaire on mediating variables contained twenty statements, comprising five statements for each mediating variable. These are provided in Table 7 below.

Table 7*Items in questionnaire on mediating variables*

Mediators:	Complexity of mental models	Cognitive flexibility	Intrinsic motivation	Cognitive persistence
Item 1	I knew what the different aspects of this problem were	I looked at this issue from many angles	I enjoyed the process of solving this problem	I kept trying to come up with new ideas even when I found it difficult
Item 2	I understood the obstacles to resolving this challenge	I considered many potential solutions before I proposed my creative solution	I thought of this as a really interesting problem to try and solve	Even after I had come up with some good ideas, I kept digging deeper to come up with better ones
Item 3	I appreciated the complexity of this challenge	I thought about this issue from other people's point of view	I thought of this as a challenge worth solving	I blocked out any distracting thoughts to ensure I was fully focused on the relevant issues
Item 4	I understood the most critical issues that need to be addressed	In evaluating potential solutions, I played out different scenarios in my head	I found myself absorbed in the process of trying to solve this problem	When an idea occurred to me, I thoroughly explored all the ways in which it could play out
Item 5	I understood the finer details of this issue	I considered how potential solutions may or may not work under different circumstances	I thought I would be interested in spending more time trying to solve this problem	I made sure that I examined all relevant aspects of the problem thoroughly

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Participants were requested to complete the questionnaire after they had worked through their creative problem solving process under the experimental condition. They were asked to compare their second experience of generating creative solutions under experimental conditions, during which they adopted specific approaches to problem construction, with their first experience of generating creative solutions under baseline conditions. Response options were:

Much less than on the 1st attempt

Less than on the 1st attempt

A little less than on the 1st attempt

The same as on the 1st attempt

A little more than on the 1st attempt

More than on the 1st attempt

Much more than on the 1st attempt

Respondents accessed the questionnaire via a link to Qualtrics, and the sliding scale enabled their responses to be recorded as continuous variables. Accordingly, they were instructed to select a response anywhere between these seven response options.

10.2.4 Demographic and control variables

Creativity scores were analysed by the participant's type of job, for which the two levels were manager or specialist, their familiarity with the app, expressed as a binary variable which reflects a high or low level of familiarity, and years' employed within the organisation.

In addition, a control variable of level of engagement was used, for which the proxy was the employee's membership of the loyalty programme. All participants were also loyalty programme members.

A Measurement of demographic and control variables

Prior to the experiment, a questionnaire on Google forms was sent to those who had agreed to participate. This questionnaire, contained in Appendix A, requested input regarding demographic and control variables.

While organisational tenure is reflected as the number of years for which the individual would have been employed at the next work anniversary, prior to analysis, the self-reported measures of familiarity with the app and job type were coded into binary variables. Responses of 'slightly familiar' or 'moderately familiar' were assigned a 0 and responses of 'very familiar' or 'extremely familiar' were assigned a 1. For the binary coding of job type, managers and staff were assigned a 0 and specialists and senior specialists were assigned a 1.

11 LIMITATIONS AND ASSUMPTIONS

Only a single experiment was conducted, of which the most noteworthy limitation was the limited sample size due to the limited availability of senior employees who were able to take the time to participate in the study. This, and the fact that the sample was drawn from a single organisation may limit the generalisability of findings. However, as it is envisaged that ultimately the normative framework informed by these research findings will be used to support creative problem solving amongst relatively senior employees, the disadvantages of the small sample size are considered to be offset by the potential gains to external validity that are offered by using senior employees as research participants.

A risk noted in the research design was the testing effect, which can pose a threat to internal validity (Schwieren, Barenberg, & Dutke, 2017). Having generated ideas to establish baseline measures, it is likely that participants may have learned or thought more deeply about the problem before generating ideas under the experimental condition. It was therefore assumed that ideas generated under experimental conditions would be more creative. This effect was managed to some extent by creating the experimental condition directly after the initial generation of ideas to establish the baseline. Most importantly however, the analysis was designed to test for the greatest difference between the baseline and experimental measures of creativity across the experimental conditions, rather than for whether or not the second score was higher or lower than the first.

Two potential types of selection bias were noted, namely self-selection bias, due to the study being restricted to those who elected to participate (Hernán, Hernández-Díaz, & Robins, 2004), and allocation bias, which refers to a bias in the way individuals are allocated to groups (Nunan, Heneghan, & Spencer, 2018). Self-selection bias could have led to participants being more likely to have an interest in and/or a natural proclivity for creative problem solving.

While in principle the risk of allocation bias was that skills in creative problem solving could have been unevenly distributed across groups, the likelihood of allocation bias was minimised by the random allocation of individuals to groups. Further assurance regarding the potential impact of allocation bias was also provided by the finding that there were no significant differences in baseline scores across the groups (see Section 14.3 below).

It could be argued that sampling from a case site like this financial services company, and the sample composition of only senior professionals limits its generalizability as the sample is not representative, but a counter argument is that this potential limitation is outweighed by the potential benefits of conducting this study in an organisation with a reputation for being particularly innovative, (Sigglekow, 2007).

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Given that the findings of this study are to inform the development of a normative framework that is sufficiently robust to facilitate improved creative problem solving amongst employees who may already be relatively proficient in this skill, it was considered important to test the proposed theory amongst this population. Furthermore, as Sigglekow (2007) argues, it may often be preferable to specifically select an organisation which is considered exemplary in order to glean insights that could not be offered by others.

Regarding the validity and reliability of measures used, while the consensual assessment technique is based on subjective assessments of a single, or in the case of this study, two, ratings of creativity, which may raise concerns about reliability, numerous studies have confirmed the reliability of resultant measures of creativity in different contexts (see Section 10.2.2).

In future studies, the measures of mediating variables could be tested further for discriminant validity and test-retest reliability. These measures could also be compared with existing measures, with the proviso that these be measures of states rather than traits.

While the purpose of this study necessitated quantitative analysis of results from an experimental design, this of course did not enable the deep probing of related issues or include an investigation into participants' qualitative experience of the experimental conditions such as could emerge from a qualitative study (Taherdoost, 2022). The subsequent action research study described in Paper 4 was designed to address this shortcoming.

Given that a process centred rather than a person centred approach has been adopted in this thesis (see Section 4.2 of Paper 1), the impact of individual differences in personality was not tested in the research design. Moreover, as individuals were randomly assigned to the groups, allocation did not control for all possible control variables. However, the analytical technique that employed comparison of each individual's scores pre and post application of the experimental condition would, to some extent, have minimized the impact of this limitation.

This experiment did not include an investigation of how other factors such as environmental contexts or group interactions may facilitate or impede the effectiveness of the approaches being tested. This limitation is addressed to some extent in the action research study, which aimed to solicit feedback on the application of the normative framework in a group context.

12 ETHICAL COMPLIANCE

Ethical risks in conducting this experiment were noted as ‘minimal’ in the ethics clearance certificate received by the University of the Witwatersrand’s Human Research Ethics Committee (Non-Medical).

To ensure that participants were fully informed of the nature of the experiment and what would be required of them, participant information sheets were distributed ahead of time. Based on this information, they were asked to volunteer for the experiment. While their involvement in the online experiments took two and a half hours, the problem that they were asked to work on was identified by the head of the division as being a problem he wanted his team to address. Therefore, while involvement in the experiment was time consuming, participants were willing to spend this time due to their interest in learning more about the creative problem solving process and their motivation to spend focussed time applying creative problem solving principles to address a real business problem. Details of the what the problem was, namely to improve the customer experience of the organisation’s app, were not shared with participants before the experiment was conducted.

All participant details were kept confidential, and judges who assessed the creativity of their solutions were not aware of which individuals had generated the proposed solutions.

Any data costs incurred during the course of the experiment were covered by the company.

Once data had been analysed, key high level findings from the experiment were shared with all participants by email, based on the interest they had expressed.

13 ANALYTICAL TECHNIQUES

13.1 Analysis to test for reliability of variables and describe data

As described above, statistical tests were conducted to establish the reliability of variables. These included Cohen’s Kappa to test for inter-rater reliability amongst creativity scores, after which it was concluded that it was preferable to conduct Spearman’s Rho and Kendall’s Tau on the ranked scores. Cronbach’s alpha was used to test inter-item reliability on the items in the mediator scales. Descriptive statistics employed in the preparation of the correlation matrix included means, standard deviations and the Pearson correlation coefficient.

13.2 Analysis to test for main and interaction effects

In the analyses conducted to compare the baseline creativity scores with the scores obtained under the four experimental conditions, the key techniques employed were the two way repeated measures mixed ANOVA and MANOVA.

Prior to conducting the MANOVA, tests were conducted to confirm required assumptions regarding the data, namely the Shapiro-Wilk test to ensure multivariate normality, the Mahalanobis distance to tests for multivariate collinearity, inspection of scatterplot matrices to test linear relationships between each pair of dependent variables for all combinations of groups of independent variables and Pearsons correlations to test for multicollinearity of dependent variables.

Baseline scores were compared to scores obtained after the application of different conditions to test for the impact of the independent variables, and scores under the different conditions were compared to test which of the conditions, if any, had a significant impact on the dependent variable.

Hereafter, the analysis technique will simply be referred to as an 'ANOVA' or 'MANOVA', but a mixed design compares the mean difference between groups that have been split on both a within-subject factor and between-subjects factors. In this study, the within-subject factor is 'time', which pertains to the first attempt to generate creative solutions under baseline conditions versus the second attempt under experimental conditions. The between-subjects factors pertain to the two independent variables of frame breadth and search type.

While the ANOVA technique was used to explore the impact of the experimental conditions on the combined creativity score, which comprised both the scores of originality and utility, analysis by MANOVA enabled exploration of whether the experimental conditions had a significant relationship with the underlying originality and utility scores as well as the combined linear relationship between these two sub-dimensions.

The advantages of using the two way repeated measures ANOVA and MANOVA include the ability to use relatively small sample sizes and the fact that these tests allow for individual variability amongst members of each sample.

Tests for interaction effects between variables were also conducted using ANOVA.

As sample sizes of each condition were equal and Box's test for equality of variance also indicated that the different conditions had equal covariance, Tukey's post hoc tests were conducted. An alpha of .15 was selected due to the small sample size.

While the convention is to use an alpha of .05, there is an argument that this significance level should not automatically be applied when the sample size is small given that statistical power will be lower with a smaller sample size, and that small samples offer lower test sensitivity. (Schneider, 2013). While one aim is to avoid a Type I error, it is also important to avoid a Type II error, which may result from using an alpha that is too low, given the sample size (Schneider, 2013). Applying the commonly used alpha of .05 reflects a conservative bias against the risk of Type I error, and the degree of this bias is naturally increased when the sample size is small (Nickerson, 2000). Given the binary nature of decision making with regard to statistical significance, the risk of making a Type II error is increased when the sample size is small, and given that the risk of a Type II error implies overlooking potentially significant findings which might merit further investigation, the implications of this conservatism should be questioned (Nickerson, 2000; Schneider, 2013).

The effect size of the two treatments of the two independent variables were calculated using Cohen's-d.

13.3 Analysis by demographic variables

Analysis of creativity scores were conducted by the demographic variable of type of job, namely whether the participant was a manager or specialist, familiarity with the app, and tenure within the organisation, as indicated above.

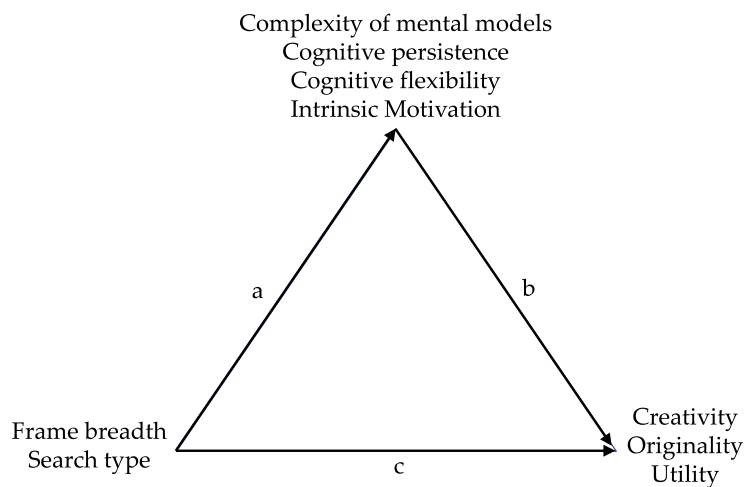
Analyses by demographic variable were conducted using stepwise regression.

13.4 Analysis by mediators

To assess the role of mediators in the concentrated curiosity model, the model developed by Baron and Kenny (1986) was used. In this model, three casual pathways are depicted, namely directly between the independent variable and the outcome variable (path c) , between the independent variable and the mediator (path a) and between the mediator and the outcome variable (path b). This is illustrated in Figure 7 below:

Figure 7

Illustration of Baron and Kenny's approach to assess Mediation



Testing for each of the four mediators proposed in the concentrated curiosity model therefore required testing of whether four conditions were met: variations in the independent variables, frame breadth and search type, would need to be significantly related to variations in the proposed mediators (path a), variations in the levels of the mediators would also need to be significantly related to the dependent variables (path b), and the direct relationship between independent and dependent variable (path c), would also need to be significant, but be weakened when the mediator is controlled.

To test for these conditions, given the repeated measures format of the experimental design, simple linear regressions were conducted to establish the effect of frame breadth and search type on each of the four mediators (path a), after which repeated measures ANOVA's were used to test the effect of the four mediators on creativity as well as originality and utility (path b) and to test the effects of frame breath and search type on creativity, originality and utility (path c).

ANCOVA's were also run to test for differences in dependent variables when mediators were held constant as covariates.

13.5 Content analysis of questions submitted

In addition to being asked to submit their creative solutions, participants were also requested to submit the questions or facts they generated as part of the exercise to research the problem. The questions submitted by the participants who had conducted the interrogative information search were analysed by conducting content analysis and post-coding questions to enable categorisation according to the type of information they were designed to elicit.

14 RESULTS OF STATISTICAL ANALYSIS

14.1 Testing of Assumptions

Assumptions relating to the research design that need to be met before conducting a MANOVA are that the dependent variables must be continuous, that the two independent variables comprise two or more categorical, independent groups, that there are mutually exclusive participants in each group, such that observations are independent and that the number of cases in each group is greater than the number of dependent variables. All of these assumptions were satisfied.

Thereafter, data was analysed to ensure that the additional assumptions of multivariate normality, linear relationships between dependent variables, no multicollinearity, and homogeneity of variance-covariance were tested. Results are provided in Appendix B.

To ensure multivariate normality, the Shapiro-Wilk test was conducted. Results showed that baseline data for both originality ($p = .28$) and utility scores ($p = .36$) are non-significant, indicating that normality of data can be assumed. Furthermore, the maximum Mahalanobis distance of 6.582 is less than the critical number of 13.82 for two independent variables, which lends additional support to the claim that multivariate collinearity has been met.

Tests of linear relationships between each pair of dependent variables for all combinations of groups of independent variables were conducted by inspecting scatterplot matrices and confirming that most matrices have an elliptical shape in the direction of bottom left to top right.

To test multicollinearity of dependent variables, Pearsons correlations were run, and as the correlation was .232, which is less than .9, the assumption of no multicollinearity between dependent variables has been met. In addition, the fact that this correlation is above .20 satisfies the assumption that these variables are related. The last assumption of homogeneity of covariance was also met as the result of Box's test of equality of covariance was $p = .926$, indicating that the null hypothesis could not be rejected.

14.2 Descriptive statistics

The tables of descriptive statistics below were derived from the various analyses conducted, namely the repeated measures ANOVA and the repeated measures MANOVA.

Table 8*Descriptive Statistics: Means and Standard Deviations of Creativity by Frame Breadth*

Measure	Breadth	Mean	Std. Deviation	N
Baseline creativity	Broad	9.79	2.70	22
	Narrow	10.46	3.47	22
	Total	10.13	3.09	44
Experimental creativity	Broad	10.80	3.13	22
	Narrow	12.20	2.77	22
	Total	11.50	3.00	44

Those who used a broad frame had slightly lower baseline creativity than those who used a narrow frame but this discrepancy more than doubled under experimental conditions. Under baseline conditions the difference between mean creativity scores was .67, whereas under experimental conditions the difference was 1.4.

Table 9*Descriptive Statistics: Means and Standard Deviations of Creativity by Search Type*

Measure	Search type	Mean	Std. Deviation	N
Baseline creativity	Factual	10.01	3.30	22
	Interrogative	10.24	2.94	22
	Total	10.13	3.09	44
Experimental creativity	Factual	10.67	2.88	22
	Interrogative	12.33	2.95	22
	Total	11.50	3.00	44

Similarly, while those who used an interrogative search had only a marginally higher level of baseline creativity than those who use a factual search, under experimental conditions this discrepancy increased more than seven-fold. Under baseline conditions the difference between means was .23, which increased to 1.66 under experimental conditions.

Table 10

Descriptive Statistics: Means and Standard Deviations of Creativity by Frame Breadth and Search Type

Measure	Breadth	Search type	Mean	Std. Deviation	N
Baseline creativity	Broad	Factual	9.88	2.95	11
		Interrogative	9.70	2.57	11
		Total	9.79	2.70	22
	Narrow	Factual	10.15	3.76	11
		Interrogative	10.77	3.30	11
		Total	10.46	3.47	22
	Total	Factual	10.01	3.30	22
		Interrogative	10.24	2.94	22
		Total	10.13	3.09	44
Experimental creativity	Broad	Factual	9.46	2.90	11
		Interrogative	12.14	2.86	11
		Total	10.80	3.13	22
	Narrow	Factual	11.89	2.41	11
		Interrogative	12.52	3.18	11
		Total	12.20	2.77	22
	Total	Factual	10.67	2.88	22
		Interrogative	12.33	2.95	22
		Total	11.50	3.00	44

The Narrow Interrogative group, followed by the Broad Interrogative group had the highest creativity under experimental conditions. Differences between baseline scores are minimal, and are not statistically significant (See Section 14.3 below).

Table 11

Descriptive Statistics: Means and Standard Deviations of Originality and Utility by Frame Breadth and Search Type

Measure	Search type	Breadth	Mean	Std. Deviation	N
Baseline originality	Factual	Broad	2.90	.57	11
		Narrow	2.99	.52	11
		Total	2.94	.54	22
	Interrogative	Broad	3.15	.64	11
		Narrow	3.20	.67	11
		Total	3.18	.64	22
	Total	Broad	3.02	.61	22
		Narrow	3.10	.60	22
		Total	3.06	.60	44
Experimental originality	Factual	Broad	2.85	.47	11
		Narrow	3.28	.41	11
		Total	3.07	.48	22
	Interrogative	Broad	3.43	.50	11
		Narrow	3.39	.57	11
		Total	3.41	.52	22
	Total	Broad	3.14	.56	22
		Narrow	3.33	.49	22
		Total	3.24	.53	44
Baseline utility	Factual	Broad	3.40	.75	11
		Narrow	3.33	.84	11
		Total	3.36	.78	22
	Interrogative	Broad	3.09	.50	11
		Narrow	3.31	.55	11
		Total	3.20	.52	22
	Total	Broad	3.24	.64	22
		Narrow	3.32	.69	22
		Total	3.28	.66	44
Experimental utility	Factual	Broad	3.29	.67	11
		Narrow	3.62	.52	11
		Total	3.45	.61	22
	Interrogative	Broad	3.53	.56	11
		Narrow	3.64	.42	11
		Total	3.58	.49	22
	Total	Broad	3.41	.62	22
		Narrow	3.63	.46	22
		Total	3.52	.55	44

Under experimental conditions, all utility scores are higher than originality scores. Only for the Broad Interrogative group, under baseline conditions, was the originality score slightly higher than utility score.

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Table 12

Correlations. Means and Standard Deviations across conditions

	Variable	Means	Standard Deviations	1	2	3	4	5	6	7
1.	Baseline Creativity	10.13	3.09	--						
2.	Baseline Originality	3.06	.60	.78**	--					
3.	Baseline Utility	3.28	.66	.78**	.23	--				
4.	Experimental Creativity	11.50	3.00	.34*	.40**	.12	--			
5.	Experimental Originality	3.24	.53	.33*	.51**	-.01	.85**	--		
6.	Experimental Utility	3.52	.55	.21	.13	.18	.82**	.41**	--	
7.	Frame Breadth	-	-	.11	.06	.06	.24	.18	.20	
8.	Search Type	-	-	.04	.20	-.13	.28	.33*	.12	
9.	Complexity	5.13	1.13	.18	.15	.12	-.08	-.11	-.01	
10.	Flexibility	4.85	.93	-.06	.05	-.14	-.15	-.14	-.11	
11.	Motivation	4.98	1.11	.04	.15	-.06	-.08	-.02	-.11	
12.	Persistence	4.80	1.03	-.12	-.14	-.07	-.19	-.14	-.17	
13.	Familiarity with the app ¹	0.73	.45	.04	.10	-.03	.17	.12	.18	
14.	Specialist vs Manager ²	.45	.50	.06	.13	-.05	.13	.09	.15	
15.	Organisational Tenure ³	6.39	3.82	.08	.10	.04	.09	.21	-.09	
	Variable	7	8	9	10	11	12	13	14	15
7.	Frame Breadth	--								
8.	Search Type	.00	--							
9.	Complexity	-.05	-.05	(.85)						
10.	Flexibility	-.06	.02	.61**	(.77)					
11.	Motivation	-.22	-.03	.61**	.63**	(.84)				
12.	Persistence	.10	-.11	.49**	.62**	.47**	(.82)			
13.	Familiarity with the app	-.10	.31*	.13	-.08	-.08	-.14	--		
14.	Specialist vs Manager	.00	.09	-.20	-.12	-.01	-.29	-.06	--	
15.	Organisational Tenure	.02	.14	-.10	-.14	.04	.09	.05	.02	--

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Note:

1. Familiarity with the app was coded as a binary variable, where responses of 'extremely familiar' or 'very familiar' were assigned a '1' whereas responses of 'moderately familiar' or 'slightly familiar' were assigned a '0'. None of the respondents selected the option 'not at all familiar'. The mean score of 0.73 therefore indicates that there was a high level of familiarity with the app.
2. Binary coding was also applied to responses of organisational role, with specialists and senior specialists being assigned a '1' and staff and managers being assigned a '0'. The mean score of .45 for this variable indicates that there was a relatively equal distribution of staff and managers versus specialists in the sample.
3. Organisational tenure was provided in years, expressed as the number of years the individual would have been employed at their next work anniversary.

In the correlation matrix above, it can be seen that most correlations are trivial or modest, but there is a moderate correlation between search type and experimental originality which is significant at the .05 level. As is discussed in Sections 14.4 and 14.5, it appears that an interrogative information search is associated with more creative solutions. It is also interesting that all mediating variables are strongly correlated with each other.

The correlation between baseline and experimental creativity is only moderate, which reflects the finding that judges found there was a change in the level of creativity in solutions proffered under experimental conditions relative to baseline conditions.

14.3 One independent variable and one dependent variable: analysis of creativity scores by group

The first one-way repeated measures ANOVA was conducted using groups as the independent variable and creativity as the dependent variable.

14.3.1 Interaction effect of groups and difference between baseline and experimental scores

The one-way repeated measures ANOVA determined that while the difference in creativity between the baseline and experimental conditions was statistically significant ($F(1, 40) = 6.971, p = .012$), there was no statistically significant interaction between the effects of group and the difference between baseline and experimental scores ($F(1, 40) = 1.416, p = .252$).

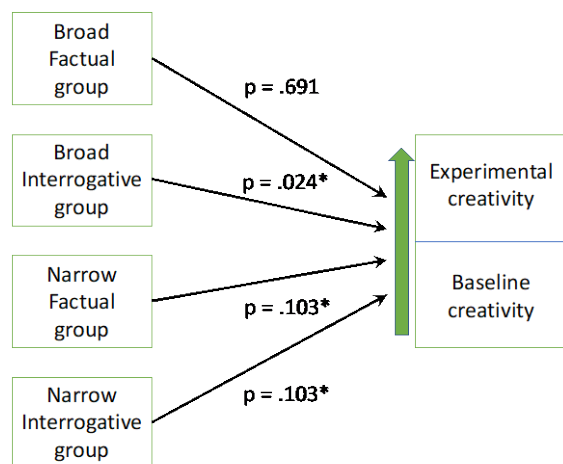
14.3.2 Within subject effects: Differences between baseline and experimental scores

When looking at main effects however, significant differences between baseline and experimental scores were found for the Broad Interrogative group ($p = .024$), the Narrow Factual group ($p = .103$) and the Narrow Interrogative group ($p = .103$), but not for the Broad Factual group ($p = .691$). The difference between baseline and experimental scores was therefore greatest for the Broad Interrogative group.

Findings are illustrated in Figure 8 below.

Figure 8

Main effects resulting from One Way Repeated Measures ANOVA



* The mean difference is significant at the .15 level

$F(1,40) = 6.971$

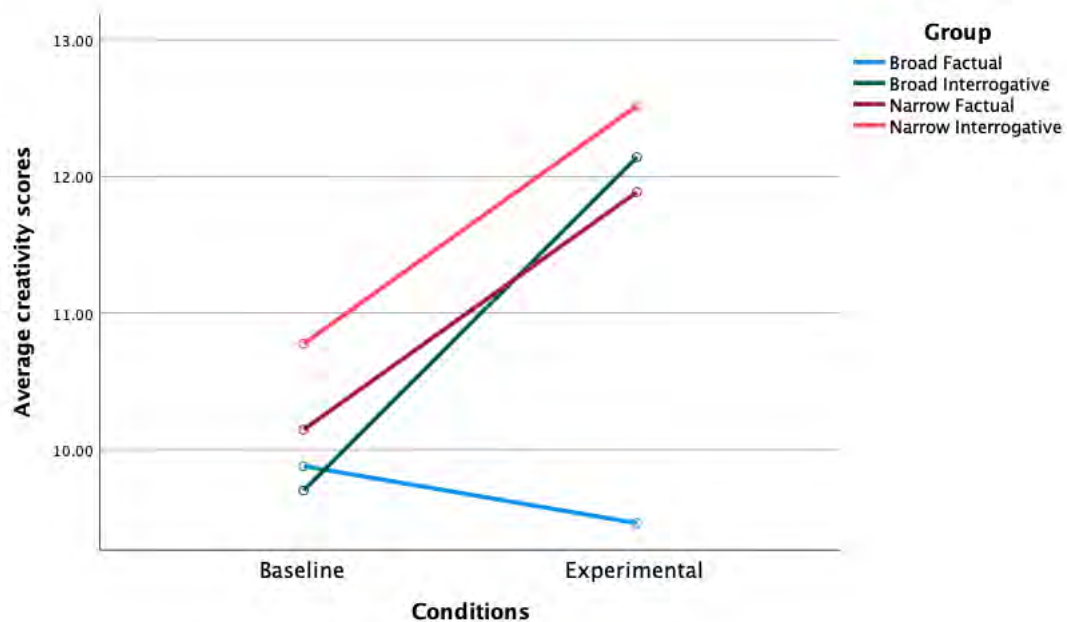
14.3.3 Between subject effects: Differences between baseline scores across groups and experimental scores across groups

There was no significant difference in creativity scores between groups under baseline conditions, but under experimental conditions, there was a significant difference between scores for the Broad Factual group and the Narrow Interrogative group ($p = .096$).

These findings are depicted in Figure 9 below, which illustrates the differences in gradients of slopes.

Figure 9

Changes in average Creativity Scores by Group



It can be seen from this graph that creativity improved significantly under experimental conditions ($F(1,40) = 6.145, p = .017$), although this was not true for the Broad Factual group, where creativity actually declined somewhat. This suggests that the increase in creativity at the second attempt could not be assumed to be solely due to experience or any inherent benefits of subsequent ideation attempts. These findings confirm, therefore, that the nature of the treatment did make a difference to the creativity of solutions proffered.

14.3.4 Effect size: relationship between independent variables and differences between baseline and experimental creativity scores

The difference between baseline and experimental creativity when using a broad frame, a narrow frame, a factual search and an interrogative search were calculated using Cohen's *d*. Results are depicted in Table 13 below.

Table 13

Effect size of differences between baseline and experimental creativity under four different experimental conditions

Independent variable	Cohen's d
Broad	0.35
Narrow	0.57
Factual	0.22
Interrogative	0.73

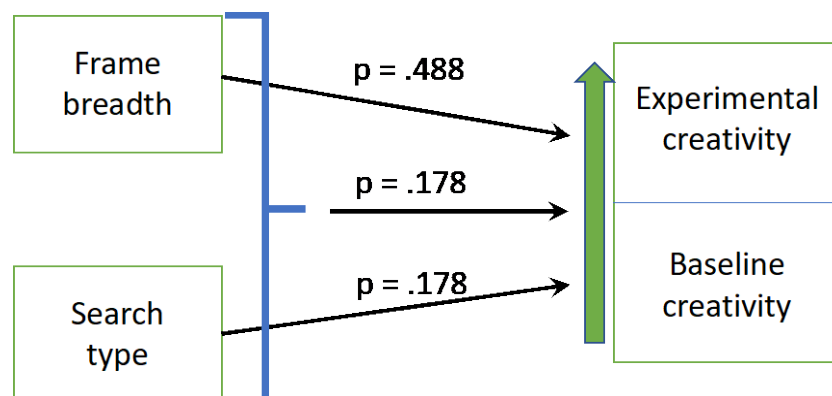
As 0.2 indicates a small effect, 0.5 indicates a moderate effect and 0.8 indicates a large effect, it can be seen that the impact of applying a broad frame and using a factual search had only a small effect on the creativity of solutions whereas applying a narrow frame had a moderate impact and the Cohen's d of 0.73 was just short of the 0.8 that would indicate a large impact.

14.4 Two independent variables and one dependent variable

The second analysis was conducted using a two-way repeated measures ANOVA, using frame breadth and search type as the two independent variables and creativity as the single dependent variable. Findings are illustrated in Figure 11 below.

Figure 10

Interaction effects resulting from Two Way Repeated Measures ANOVA



$$F(1,40) = 1.876$$

14.4.1 Interaction effect between independent variables and baseline vs experimental scores

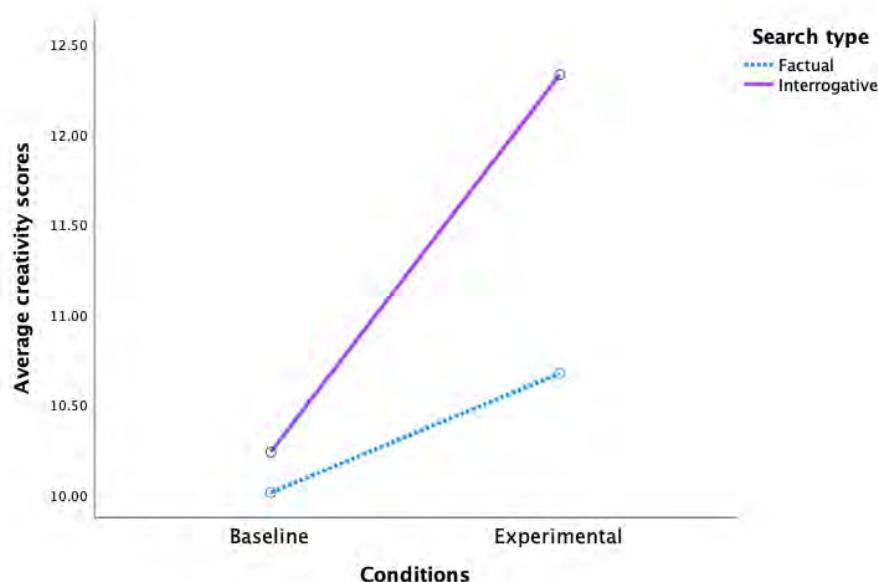
Results of the analysis of the separate effects of the independent variables of frame breadth and search type indicated that the interaction effects between each independent variable and baseline versus experimental creativity scores was not significant, with p values of $p = .488$ and $p = .178$ respectively. The interaction effect of frame breadth in combination with search type was also not found to be significant ($p = .178$).

14.4.2 Main effects: relationship between independent variables and differences between baseline and experimental creativity scores

Those who used an interrogative search significantly improved their creativity under experimental conditions ($p = .007$) whereas those who used a factual search did not increase their creativity significantly under experimental conditions ($p = .375$). The relative gradients of these changes are illustrated in Figure 12 below.

Figure 11

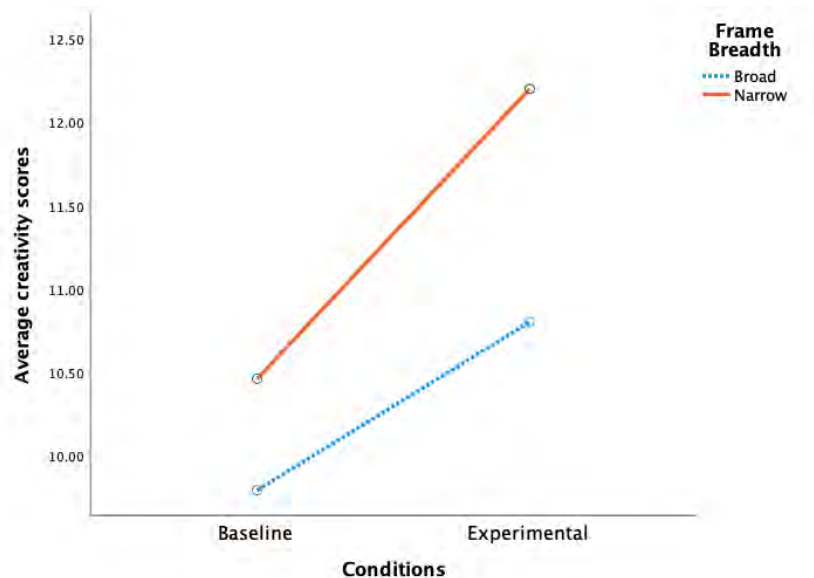
Changes in Creativity Scores by Search Type



Similarly, those who used a narrow frame increased their creativity significantly under experimental conditions ($p = .023$) whereas those who used a broad frame did not increase their creativity significantly ($p = .178$). The difference in gradients is illustrated in Figure 13 below.

Figure 12

Changes in average Creativity Scores by Frame Breadth



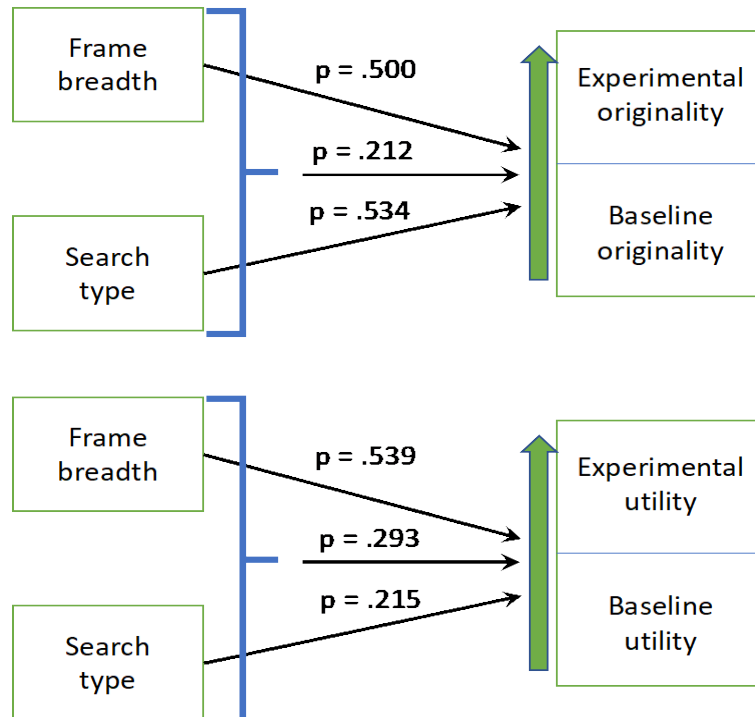
As alluded to in Section 14.3 however, it was interesting that when looking at the combination of independent variables, for those who used a narrow frame, search type had no discernible impact on the improvement of their creativity over time. However, for those using a broad frame, search type did have an impact, with those using a factual search actually delivering less creative solutions over time, whereas those who used an interrogative search increased their creativity significantly over time ($p = .024$).

14.5 Two independent variables and two dependent variables

The third approach to the analysis was conducted to establish the relationship between independent variables of frame breadth and search type and the dependent variables of utility and originality under baseline and experimental conditions. For this purpose, ANOVAs and a MANOVA were conducted on the difference between baseline and experimental scores of both originality and utility. A two-way repeated measures MANOVA was also conducted, for which the results were the same as the MANOVA on the difference between baseline and experimental scores. Results of this additional analysis have therefore not been reported here. The high level results of the ANOVA analysis are illustrated in Figure 14 below. Thereafter, additional findings from these analyses are discussed.

Figure 13

Interaction effects resulting from Two Way ANOVA on differences between Baseline and Experimental Originality and Utility



14.5.1 Interaction effects between independent variables and baseline vs experimental dependent variables

Interaction effects emerging from the ANOVA's conducted on the difference between baseline and experimental originality and utility did not provide evidence of a statistically significant effect of either frame breadth or search type on these two components of the creativity score.

This being said, the combination of frame breadth and search type, as expressed by the interaction effect ($F(1,40) = 1.610$, $p = .212$) had a stronger impact on originality than these two conditions on their own, expressed in the main effects of frame breadth ($F(1,40) = .464$, $p = .500$) and search type ($F(1,40) = .394$, $p = .534$). On the other hand, search type on its own had a stronger relationship with the difference in utility scores ($p = .215$) than did the combined effect of frame breadth and search type ($p = .293$).

In the two-way repeated measures MANOVA, creativity is a linear relationship between the two sub-scores. In comparison, in the ANOVA, creativity scores are a product of originality and utility. Results of the MANOVA also did not reveal any statistically significant interaction between the effects of frame breadth and the overall creativity scores at baseline versus experimental conditions, ($F(1, 40) = .610$, $p = .439$).

A significant interaction between the effects of search type and the overall creativity scores at baseline versus experimental conditions could also not be detected by the repeated measures MANOVA ($F(1, 40) = 1.445, p = .236$). But again, the results of this analysis also indicated that the interaction effect ($F(1,40) = 1.938, p = .172$) was stronger than the main effects.

14.5.2 Comparing originality and utility scores and their changes over time

It was interesting that originality scores were significantly lower than utility scores ($p = .005$). This was true under baseline conditions ($p = .064$) and even more so under experimental conditions ($.003$). Both originality and utility scores improved significantly under experimental conditions with very similar improvements reflected in originality ($p = .042$) and utility ($p = .051$).

14.5.3 Main effects between frame breadth, originality and utility

When analysing the impact of frame breadth by comparing the creativity sub-scores of the Broad Interrogative and Broad Factual group with those of the Narrow Interrogative and Narrow Factual groups, it was found that originality and utility did not increase significantly under experimental conditions when the frame was broad but did increase significantly when the frame was narrow. When frames were narrow, the increase in originality ($p = .056$) was marginally more significant than the increase in utility ($p = .070$).

14.5.4 Main effects between search type, originality and utility

When comparing the creativity sub-scores of the Broad Interrogative and Narrow Interrogative groups with those of the Broad Factual and Narrow Factual groups, it was found that neither originality nor utility increased significantly for the Factual groups but they did increase significantly for the Interrogative groups. For the Interrogative groups, the increase in utility ($p = .026$) was marginally more significant than the increase in originality ($p = .061$).

14.5.5 The relationship between the combination of frame breadth and search type, and originality and utility

The ANOVA on the difference in utility showed that the improvement in utility was significantly greater amongst those who used a broad frame and an interrogative search than those who used a broad frame and a factual search. ($p = .108$). In contrast, when the frame is narrow, whether the search type is factual or interrogative does not appear to have a material impact on the utility of solutions. ($p = .892$).

It can also be seen from the repeated measures MANOVA that utility only increased significantly for those using a broad frame and an interrogative search ($p = .070$) and that there was a difference in the increase in utility, albeit non-significant, between those who used a narrow frame and an interrogative search ($p = .165$) and those who used a narrow frame and a factual search ($p = .229$).

The improvement in originality was also significant when a broad frame was accompanied with an interrogative search, but this improvement was not significantly greater than when a factual search was used ($p = .187$). As was the case with utility, when the frame was narrow the improvement in originality did not differ significantly according to whether a factual or interrogative search was used ($p = .653$). The repeated measures MANOVA again provided more detailed insights into these relationships, revealing that the increase in originality was actually greatest for those who used a narrow frame and a factual search ($p = .095$) followed closely by those who used a broad frame and an interrogative search ($p = .106$). These findings are illustrated in the graphs in Figure 15 and Figure 16 below.

Figure 14

Results of MANOVA on difference between baseline and experimental utility

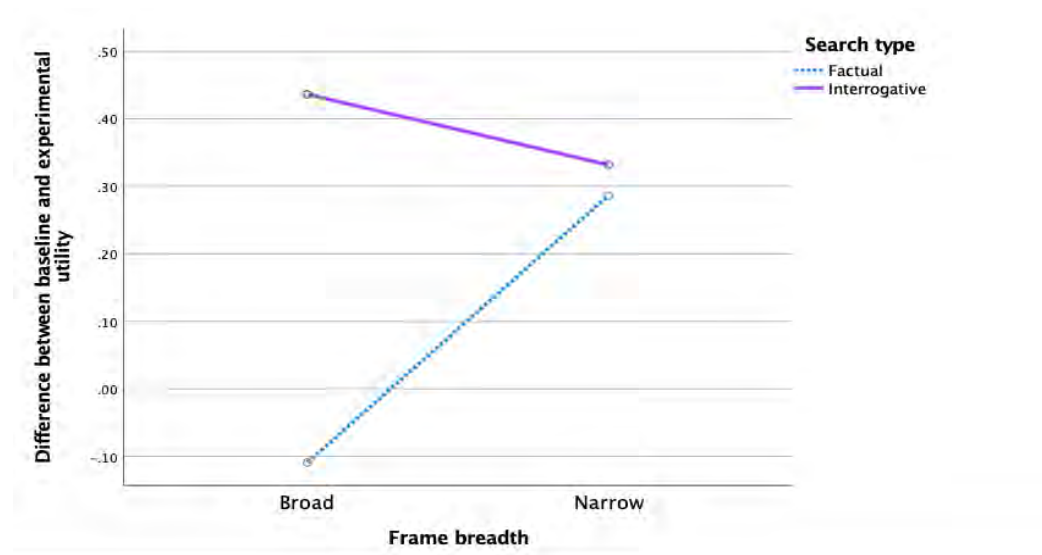


Figure 15 above illustrates that while utility improved more for those using an interrogative information search when this was accompanied by a broad frame, this difference is only marginal when compared to those using an interrogative search and a narrow frame. On the other hand, when a factual search is conducted, utility improved far more when a narrow frame was used than when a broad frame was used.

Figure 15

Results of MANOVA on difference between Baseline and Experimental Originality

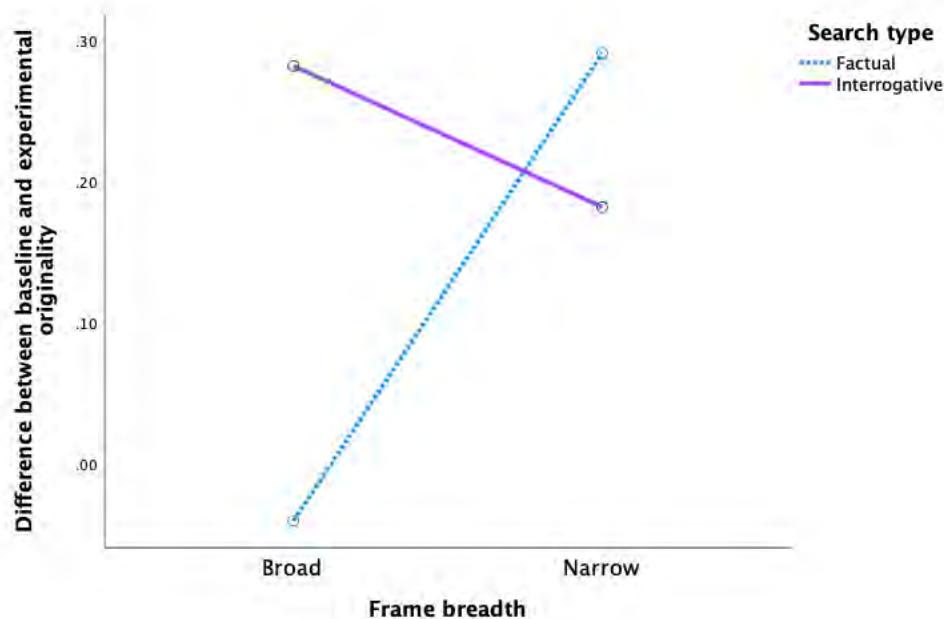


Figure 16 clearly illustrates that the difference in originality exhibits a similar pattern to that found for utility, but is even more marked when a factual search is used. When conducting a factual search, a narrow frame is far more advantageous than a broad frame in increasing originality. When conducting an interrogative search, the frame breadth doesn't make as much difference to the increase in originality, even though a broad frame is preferable.

14.6 Assessing the role of mediators

Self-reported measures of changes in state after the second attempt at problem solving, namely under experimental conditions, indicated that on average, participants reported greater complexity in their mental model of the problem, enhanced cognitive flexibility, greater intrinsic motivation and employed greater cognitive persistence during the second attempt, compared to the first. The response format for all four mediating variables was

- 1= *Much less than on the 1st attempt*
- 2 = *Less than on the 1st attempt*
- 3 = *A little less than on the 1st attempt*
- 4 = *The same as on the 1st attempt*
- 5 = *A little more than on the 1st attempt*
- 6 = *More than on the 1st attempt*
- 7 = *Much more than on the 1st attempt*

Average responses to questions regarding changes in each of these mediating variables are provided in Table 14 below.

Table 14

Means and Standard Deviations of Mediators

Mediator	Mean	Std. Deviation	N
Complexity	5.13	1.13	44
Flexibility	4.85	0.93	44
Motivation	4.98	1.11	44
Persistence	4.80	1.03	44

On average, the dimension reported to have been most enhanced was the complexity of the mental model of the problem. While self-perceptions of the increase in all dimensions were positive, they were modest. To explore which of the experimental conditions, if any, had the greatest relationship with these mediator scores, a two-way ANOVA was conducted, the results of which are provided in Table 15 below.

Table 15

Results of Two Way ANOVA to explore relationship between Independent Variables and Mediators

Independent variable	Measure	P value
Breadth	Complexity	.743
	Persistence	.534
	Flexibility	.677
	Motivation	.149*
Search type	Complexity	.751
	Persistence	.483
	Flexibility	.901
	Motivation	.836

* The relationship is significant at the .15 level

This analysis revealed that motivation varied significantly by frame breadth, with intrinsic motivation being significantly higher amongst those who used a broad frame rather than a narrow frame ($p = .149$).

Using Baron and Kenny's approach as discussed in Section 13.3, simple linear regressions were run to determine the impact of frame breadth and search type on the difference in creativity scores as well as the sub-dimensions of the difference in originality and utility scores (path c). Results are shown in Table 16 below.

Table 16

Results of Linear Regression between Independent Variables and difference between Baseline and Experimental scores for Dependent Variables (Path c)

Independent variable	Measure	Standardised	
		Beta value	P value
Breadth	Difference in Creativity	.105	.497
	Difference in Originality	.105	.500
	Difference in Utility	.094	.542
Search type	Difference in Creativity	.206	.179
	Difference in Originality	.096	.534
	Difference in Utility	.192	.212

The relationships of frame breadth and search type with the difference in creativity were not significant ($p = .497$ and $p = .179$ respectively), and neither were the relationships with the sub-dimensions of originality ($p = .5$ and $p = .534$ respectively) or with utility ($p = .542$ and $p = .212$ respectively). Given that the total effect of the model was not shown to be significant by these results, the additional linear regressions to explore the relationships between paths a and b were not necessary to establish whether the four variables of complexity of mental models, cognitive persistence, cognitive flexibility and intrinsic motivation could be shown to act as mediators in this model. Nevertheless, additional simple linear regressions were conducted to establish if there were any relationships of interest to be noted in paths a and b. Results of the analysis for path a are provided in Table 17 below. Results differ only marginally from those of the 2 way ANOVA analysis results contained in Figure 14 above.

Table 17

Results of Linear regression between Independent Variables and Mediators (Path a)

Independent variable	Measure	P value
Breadth	Complexity	.738
	Persistence	.527
	Flexibility	.677
	Motivation	.145*
Search type	Complexity	.746
	Persistence	.475
	Flexibility	.901
	Motivation	.839

* The relationship is significant at the .15 level

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In exploring the relationships in path a, a significant relationship found between the independent variables of frame breadth and search type and these four variables was, as was seen from the results of the 2 way ANOVA, that intrinsic motivation was higher amongst those who used a broad frame rather than a narrow frame ($p = .145$).

Linear regressions were also run to explore the relationship between the four proposed mediators in the model and the difference between baseline and experimental creativity, originality and utility (path b).

The results of these analyses are provided in Table 18 below.

Table 18

Results of Linear Regression between Mediators and difference between Baseline and Experimental scores for Dependent Variables (Path b)

Independent variable	Measure	P value
Complexity	Difference in Creativity	.148*
	Difference in Originality	.086*
	Difference in Utility	.466
Flexibility	Difference in Creativity	.635
	Difference in Originality	.249
	Difference in Utility	.818
Motivation	Difference in Creativity	.491
	Difference in Originality	.249
	Difference in Utility	.854
Persistence	Difference in Creativity	.711
	Difference in Originality	.893
	Difference in Utility	.711

* The relationship is significant at the .15 level

These analyses revealed a significant relationship between complexity of mental models and creativity (.148) and a stronger significant relationship between complexity of mental models and the underlying score of originality (.086).

Although, as discussed above, the data did not support the primary model, such that additional tests on proposed mediators were not required, a two way repeated measures ANCOVA was then run on the primary model, using complexity as the covariate. Results of this analysis were that when complexity is held constant, the relationship between breadth and creativity decreases marginally from $p = .497$ to $p = .532$ and the relationship between search type and creativity also decreases slightly from $p = .179$ to $p = .196$.

P values are therefore 6% lower for breadth and creativity and 8% lower for search type and creativity when complexity is added into the model as a covariate.

The same analysis was conducted using the sub-score of originality as the dependent variable in the ANCOVA, from which it was found that again the relationship between both breadth and originality as well as search type and originality decreased marginally from $p = .500$ to $p = .549$ and from $p = .534$ to $p = .583$ respectively. These represent decreases in the p value of 9% and 8.5% for breadth and search type when complexity is added as a covariate. The ANCOVA was not conducted using utility as the dependent variable given that results of the linear regression depicted above did not suggest a significant relationship between complexity and utility.

Therefore while the results of the analysis did not satisfy the conditions for mediation, the statistically significant relationships found between complexity and creativity, but more specifically between complexity and originality, and between intrinsic motivation and the breadth of the problem frame are interesting and will be commented in the discussion of results (See Section 16).

14.7 Analysis by Demographic variable

As indicated in Section 10.2.4 above, in the questionnaire administered to participants prior to their participation in the experiment, they were asked whether they were members of the loyalty programme as a proxy for indicating level of engagement in the programme. This variable was therefore added as a control variable. Responses showed that all participants were also members.

The three demographic variables recorded in this experiment were organisational tenure, defined as number of years employed, familiarity with the app, which was transformed to a binary measure of slightly or moderately familiar (0) or very or extremely familiar (1), and job type, which was also transformed to a binary measure, whereby staff and managers were assigned a code of 0 and specialists or senior specialists were assigned a code of 1.

Analysis by MANCOVA indicated that controlling for these variables did not have a significant impact on either originality or utility of solutions.

Three stepwise regressions were also performed with these variables as independent variables and the difference in creativity, originality and utility as the dependent variables. No significant relationships were detected, as depicted in Table 19 below.

Table 19*Results of Stepwise Regression between Demographic Variables and Dependent Variables*

Independent variable	Dependent variable	Sig (1 tailed) P value	Pearson correlation
Tenure	Difference in creativity	.485	.006
	Difference in originality	.301	.081
	Difference in utility	.273	-.093
Familiarity	Difference in creativity	.238	.049
	Difference in originality	.498	-.001
	Difference in utility	.158	.155
Job type	Difference in creativity	.363	.015
	Difference in originality	.371	-.051
	Difference in utility	.162	.152

15 RESULTS OF CONTENT ANALYSIS OF QUESTIONS SUBMITTED

Questions submitted by participants as those they had raised in their interrogative information search were analysed and post-coded on the basis of the type of answer they were designed to elicit. The resultant categorization of types of questions provided insight into the scope of questions posed.

Questions within each category of question were then reviewed to assess the depth of interrogation suggested by specific questions.

15.1 Scope of questions posed

Categories of questions that emerged are described in Table 20 below. Results of this analysis were that, of the 220 questions submitted by the 22 participants who conducted interrogative information searches, questions were classified as follows:

Table 20

Categories of questions posed by participants in the interrogative information search

Category of question:	Number of questions in this category	Percentage of questions in this category
Solutions	80	36.3
Insights	75	34.0
Outcomes	36	16.4
Obstacles	15	6.8
Context	14	6.4
Total	220	100

15.2 Types of questions posed in each category

Questions in the Solutions category were all aimed at reflecting on possible solutions. Examples of such questions include: “How can we increase member retention within the app?”, and “How do we make it easier to navigate?” It is noteworthy that despite the fact that participants were specifically instructed to avoid asking questions about the solutions, but rather questions about the problem itself, the majority of questions were about solutions. Furthermore, of the items submitted as questions, 34 were also ideas rather than questions.

Questions in the Insights category referred primarily to the need for insights into preferences and behavioural proclivities of users. Examples of these questions were: “When does the app experience begin?” and “What motivates people to use apps?” Questions about Outcomes were typically quite broad rather than specific - examples being “What do users ultimately want to get out of using the app?” and “What emotion do we want to evoke?”. Questions were not posed to probe potential answers in more depth.

It was also interesting that there were relatively few questions about Obstacles, given that these might form the focus of problem solving efforts. Examples of such questions were: “Where are we overloading working memory?” and “What are the negatives about the app? What do people hate most about it?”. Again, these questions did not probe potential areas of dissatisfaction in depth.

Most of the questions in the Context category pertained to the competitive context, and only 3 of the 14 classified as contextual questions were related to trends such as emerging technology. Examples of questions in this category included “Who are the competition?”, “What apps are the most engaging?” and “Is our tech team knowledgeable on the latest technology?”.

15.3 Use of the prescribed iterative approach to using facts to generate questions

In the guidelines provided on how to conduct an interrogative information search, participants were instructed to use each new fact or piece of information that emerged as a springboard or a stepping stone to formulating another question. The prescribed approach was therefore to move from question to answer to question to answer etc.

In the analysis of questions, it was seen that only 2 of the 22 participants asked to conduct an interrogative information search actually used this approach as intended. There were an additional 6 participants who generated questions from questions. The remaining 14 participants generated questions that did not seem to follow on directly from each other, although they may have been inspired by the line of thought sparked by a previous question.

16 DISCUSSION OF FINDINGS

The aim of this experiment was to empirically test the hypotheses that inform the concentrated curiosity model that has been proposed to explain an approach to optimise creative problem solving.

The first hypothesis proposed is that using an interrogative information search, which involves a process of continual questioning based on information gleaned, will be more conducive to creative problem solving than an information search in which facts are simply noted.

The second hypothesis is that problem frames comprising sub-problems of underlying concepts (namely narrow problem frames) will elicit greater creativity than a broad problem frame, and the third hypothesis is that an interrogative information search and the sequential focus on sub-problems (namely narrow problem frames) will be mutually reinforcing in supporting the creativity of solutions.

Furthermore, in the model, it was proposed that the four variables of cognitive persistence, intrinsic motivation, cognitive flexibility and complexity of mental models act as mediators between the two independent variables of search type and frame breadth and the dependent variable, namely, the creativity of solutions proposed.

The experiment was conducted to explore the effects of the two independent variables of search type and frame breadth. In this experiment, four groups of managers from the company were asked to generate creative solutions as to how to improve the user experience of their app.

To establish baseline measures of individual creativity, individuals in all groups generated their first solutions without receiving any instructions on how to construct the problem. Thereafter, individuals in each of the four groups were given different instructions as to how to construct the problem, such that each group used a different combination of the two variables.

Each individual's experimental scores were compared with their own baseline scores of creativity, with creativity having been measured using the consensual assessment technique. The overall measure of creativity was calculated as the product of two sub-scores of originality and utility.

Just before the end of the experiment, individuals were asked to answer a questionnaire regarding their perception of any change they might have experienced in their cognitive persistence, intrinsic motivation, cognitive flexibility and the complexity of their mental models of the problem – comparing their experience of their first and second attempts at generating creative solutions.

Key findings from the statistical analysis are described below.

16.1 Interrogative information search and narrow frames associated with greater increase in creativity

Findings from the analysis of main effects and calculation of the effect size support the first and second hypotheses. In the simple analysis of the difference between creativity scores under baseline versus experimental conditions, a notable divergence was detected, with those who used a narrow frame and those who used an interrogative search under experimental conditions exhibiting a far greater increase in their creativity than those who used the alternative approaches. More specifically, while the use of a narrow frame was associated with a significant increase in creativity, the use of a broad frame was not. Analysis of the effect size yielded similar results, with the difference between baseline and experimental creativity exhibiting only small effect sizes with the use of a broad frame and a factual search, but a moderate effect with the use of a narrow frame and an effect size that fell just short of being classified as large with the use of an interrogative search.

Similarly, the use of an interrogative information search was associated with a significant increase in creativity, while the use of a factual search was not. A stronger relationship was found between search type and creativity than between frame breadth and creativity.

Interaction effects did not support the first and second hypotheses. It is suggested that, given the small sample size which limits the ability of more sensitive analytical techniques to detect significant differences in the data, this analysis of main effects is noteworthy. While interaction effects were not found to be significant, this is most likely due to limited power resulting from the relatively small sample sizes, especially as considerably greater power is required to show interaction effects than main effects (Leon & Heo, 2009).

It should also be noted that while the aim of using narrow frames was to focus attention on specific aspects of the problem in order to foster perspectives that may not have been previously considered, the impact of using these narrow frames may have been dampened by participants' familiarity with these problems. Such familiarity as well as the time and effort already spent by these participants in trying to come up with solutions would have made it likely that there were few aspects of the problem that had not been previously considered. In the study conducted by Reiter-Palmon et al. (1997), as discussed in Paper 1, it was similarly suggested that their attempts to encourage active processing of problem construction may have failed due to their research participants' familiarity with the problems they were addressing.

16.2 Different combinations of frame breadth and search type have different effects on creativity

Findings did not support the third hypothesis, as no significant positive interaction between a narrow frame and an interrogative search could be detected. However, the different combinations of the two variables did appear to have different effects on creativity. The greatest increase in creativity scores under experimental conditions was found in the Broad Interrogative group, which is contrasted with a decrease in creativity in the Broad Factual group. While the theoretical principles informing the concentrated curiosity model would predict that the Broad Factual group would experience the lowest increase in creativity under experimental conditions, the finding that there was in fact a slight decrease was surprising, given the expected increase due to the testing effect (Schwieren, Barenberg, & Dutke, 2017). As this decrease in average scores was only 4%, it might be said to be negligible, but the prediction of the relatively lower increase in creativity in the Broad Factual group was certainly supported by these results.

It is also noteworthy that while it might be assumed that the second solutions submitted would always be more creative than the first, due both to the effects of learning and deeper consideration of the problem (Schwieren et al., 2017), as well as the likelihood that the problem solver's initial solutions will be less original due to greater cognitive availability (Ward, 1994), the finding that this was not true for all groups implies that the approaches applied to the problem construction under experimental conditions did have an impact on the creativity of solutions.

The hypothesis that the combined effect of a narrow frame and an interrogative search would result in the Narrow Interrogative group undergoing the greatest increase in creativity was not born out by the findings. Rather, it was found that the increase was greatest for the Broad Interrogative group. A potential explanation for this finding is that given that the Broad Interrogative group had the lowest baseline creativity while the Narrow Interrogative group had the highest baseline creativity (see Table 10), it could be argued that the improvements to creativity from an already high base were harder won than the gains from a low base, as would be predicted by the S-curve description of incremental innovation (Christensen, 1992). The gains achieved by those in the Narrow Interrogative group, by participants who were already the most creative, could therefore be said to represent a greater improvement than would be predicted by the S-curve, which posits that at higher performance levels, marginal improvements tend to flatten out.

While this potential explanation may be worthy of consideration, the significantly greater improvement in creativity experienced by individuals in the Broad Interrogative group is also not surprising given the position of creativity researchers who argue that even when applying constraints in problem framing may be beneficial, the scope of frames should initially be broad (Finke et al., 1992). This finding has therefore been used to inform the development of the normative framework.

16.2.1 Search type matters with a broad but not a narrow frame

It was interesting that for those who used a narrow frame, creativity increased at the same rate, regardless of search type ($p = .103$). However, when a broad frame was used, search type made a notable impact, as those who used a factual search experienced a slight dip in creativity and those who used an interrogative search experienced the greatest increase in creativity ($p = .024$). (See Figure 8)

A possible explanation of the decrease in the creativity of the Broad Factual group is provided here. As discussed in Section 5.2.2 of Paper 1, the application of constraints has been shown to be effective in problem construction (Medeiros, Steele, Watts & Mumford, 2018; Mumford, Baughman, Threlfall, Supinski & Costanza, 1996).

Participants in the Broad Factual condition however, were not required to impose any constraints in their problem construction and in fact were encouraged to expand the scope of the problem frame— firstly by using a broad frame and secondly by using an information search that did not require that they follow any specific guidelines, such that their default approach towards gathering information was allowed.

While research does indicate that a broader information search supports more creative solutions (Harms et al., 2020), it also suggests that the value of an information search for the purposes of creative problem solving should be assessed on the basis of the information that it yields, which should ideally be "...diverse, inconsistent, or paradoxical information..." (Harms et al., 2020, p.10) It is argued here, however, that a broad problem frame in itself will not ensure a broad search that may generate such a diverse range of insights. In fact Dennis et al. (1996) cite a number of studies which support their assertion that when confronted with a broad problem, individuals will focus only on very limited sub-sections of this problem space. This problem may also be compounded by the problem solver's tendency to assume that the liberty to explore a broad problem frame has indeed enabled them to establish a comprehensive perspective on the problem (Dennis et al., 1996).

Another factor that could be at play here, is that if it can be assumed that a lower level of active engagement is demanded by a factual search than an interrogative search, as has been argued in the theory presented in Paper 1, a factual search would require less active processing of information. When incoming information is not actively processed then it is not used to expand or challenge current mental models (Russo et al., 1996), which may allow for fixation (Dane, 2010).

The lower levels of creativity exhibited by the Broad Factual group under experimental conditions may therefore, at least in part, be due to an information search that was both limited in scope and less actively processed - both factors which would have supported maintenance of established mental models. Such complacency in existing mental models would be likely to support the assumption that initial solutions already proffered would have reflected their most creative ideas.

In the case of the Broad Interrogative group, while again the broad frame might have limited the scope of the information search as described above, this limitation could have been offset by the active processing necessitated by the reflection and question generation required by the interrogative search. This active engagement, coupled with the ability to extend the search into more diverse areas enabled by the broad frame, might explain this group's higher levels of creativity.

Clearly, however, the nature of the search had a significant impact when a broad frame was used, with the interrogative search delivering a distinctive advantage.

In both Narrow Factual and Narrow Interrogative groups, the restricted focus to only two narrow problem frames may have limited the ability of both the factual and interrogative search to generate a diverse range of insights. Although it was hypothesised that the Narrow Interrogative group would then have to generate deeper insights, the potential benefits of a deeper search may have been outweighed by the disadvantage of imposing this constraint prior to the information search.

The implication of this finding is addressed in the development of the normative framework in Paper 3.

16.3 Analysis of creativity sub-scores by frame breadth and search type

When reviewing the main effects of frame breadth and search type on their own, it was found that originality and utility increased significantly only when the frame was narrow rather than broad, or when the search was interrogative rather than factual.

However, when considering which combination of frame breadth and search type was most conducive to the increase in both originality and utility of solutions, a broad frame coupled with an interrogative search was the most effective problem construction. For utility, search type on its own was most impactful, with the interrogative search being more effective than the factual search. For originality, the combination of frame breadth and search type played a more impactful role in increasing originality scores than either variable on their own. In the case of originality, the combination of a narrow frame and factual search or a broad frame and interrogative search were similarly effective.

A possible explanation is that for a potential solution to be of practical value, it is important to consider the potential ramifications of that solution, such as would be facilitated by an interrogative search, and that such interrogation would be valuable whether probing issues directly or more tangentially related to the problem. For an idea to be original, on the other hand, a broad scan for facts about the problem may result only in familiar concepts emerging. Therefore, a broad search would need to be interrogative or probing in order to unearth less superficial insights. When looking for information within a more narrowly defined scope, a factual search may suffice to look for facts about the problem, as even a factual search would require the problem solver to ‘dig deep’ to uncover facts about a very specific issue. In looking for information that could spark more original ideas therefore, either the narrow problem frame or the interrogative information search could be used to elicit a more effortful search that would deliver more unusual insights that could facilitate the generation of more original ideas (See discussion in Section 6.7.1A).

It is also possible that, as suggested by the findings from the qualitative analysis of questions generated (see Section 15), these research participants may have benefitted from more specific guidelines regarding the interrogative information search, as they might not have used the interrogative information search optimally when probing the narrowly defined problem.

It is recommended therefore, that if both originality and utility of the solution are to be considered, the problem construction should ideally employ an interrogative search based on a broad frame. Thereafter, the benefits of narrow framing may be leveraged to focus ideation efforts. (See Paper 3.)

16.4 Analysis of mediators

As the concentrated curiosity theory included the four mediators in explanations of relationships between independent variables and dependent variables, it was considered appropriate to test the role of these variables in the model. While most findings in this analysis were not significant, the inclusion of this analysis was important to ensure comprehensive testing of the concentrated curiosity theory. Different factors may be responsible for the finding that mediators do not appear to play a role in explaining the relationship between the independent variables and the dependent variables, the most obvious of which may be the limited sample size, which limited the power of statistical tests.

It is noteworthy, however, that despite the participants' high degree of familiarity with the app, as well as the time and attention already spent on trying to solve the problem, complexity of mental models was the dimension found to have increased the most under experimental conditions, and this dimension did have a significant relationship with the increase in creativity, and specifically, with the increase in originality, which lends some support to this explanation.

The analysis to determine whether the proposed mediators were in fact mediating the relationship between the independent and dependent variables yielded a second interesting finding, namely that the use of a broader problem frame was associated with higher levels of intrinsic motivation. This is interesting in light of the finding that those who used narrow frames tended to submit more creative solutions. One possible interpretation is that as creative thinking is not easy, enjoyment of the process may not be a requirement, and those who have to struggle with the challenge of thinking within restricted parameters may enjoy the process less but deliver more creative ideas. This interpretation could be supported by the analogous finding that those working in more diverse groups enjoyed the experience less than those working in homogenous groups but produced more creative output (Kurtzberg, 2005).

While the increase in cognitive persistence itself was not significantly related to the increase in creativity, it bears mentioning that complex mental models are developed through cognitive persistence (see Section 6.2.1 of Paper 1) and so while cognitive persistence itself may not have been shown to be a mediator in this model, again perhaps due to the self-perception that cognitive persistence had only increased modestly, the increased complexity of mental models is likely to have resulted from an increase in cognitive persistence.

The finding that there was a strong correlation between mediating variables also merits comment. Firstly, the strong relationships between mediators is an intrinsic element of the model, so the high correlations are to be expected. Secondly, this may be due to halo effects such that if the participant perceived that their experience under experimental conditions was more positive in a certain respect, they might judge their experience more favourably in other respects. However it should be noted that as the correlations range from .49 to .63, these are not sufficiently high to suggest that the measures of these variables have not distinguished effectively between the constructs.

16.5 Analysis by demographic variables

Although the strongest relationships detected were between familiarity and utility as well as job type and utility, in general the change in creativity scores after applying experimental conditions was not influenced by the demographic variables of organisational tenure, familiarity with the app and job type. This result suggests that the role of the concentrated curiosity model is not influenced by the problem solver's level of experience or seniority.

16.6 Insights gleaned from qualitative analysis of questions submitted

Although participants were given instructions on how to conduct an interrogative information search, accompanied with slides containing visual illustrations of the underlying principles, analysis of questions submitted clearly indicated that participants were not easily able to follow this process. The predominant approach was to propose potential solutions instead of posing questions or to pose questions about solutions, rather than the problem. This may be due to the prevalent tendency to look for solutions and a relative discomfort in maintaining focus on an unresolved problem (Basadur & Basadur, 2011; Locke et al., 2008). It was also found that questions that were posed about the problem itself were limited in both scope and depth.

This underscores the need for a normative framework that specifically guides problem solvers on how to explore the problem and actively search for and process both new and anomalous information (Harms et al., 2018; Illies & Reiter-Palmon, 2004; Mumford, Baughman, Supinski & Maher 1996; Steele et al., 2017).

The finding that participants did not effectively follow the questioning process as it was explained to them also indicates that principles and guidelines alone are unlikely to be sufficient in facilitating the interrogative information search, but rather that there is a need for specific questions to be included in the interrogative information search framework such that these can serve as prompts to guide problem solvers through the process. This is addressed in the development of the normative framework in Paper 3 of this thesis.

17 IMPLICATIONS FOR PRACTITIONERS

A clear outcome from these findings is that the approach used in searching for information about the problem and the scope of focus of the problem frame has a significant impact on the creativity of solutions subsequently generated. The fact that these effects were encountered amongst senior, highly experienced employees who have already dedicated a considerable amount of time trying to come up with solutions to this central problem, underscores the value of the role that these two variables can play in enhancing creativity.

Furthermore, it is noteworthy that the positive impact of the interrogative information search emerged even when participants did not pose questions using the iterative approach they were requested to follow. It appears therefore, that there is value in simply generating questions, even if this is not conducted such that questions are used to probe incoming information.

Another important outcome of this experiment was the finding that creativity improves with an increase in complexity of the mental model of the problem. The finding that increased complexity was even more strongly associated with originality is worth noting, as it was found to be more challenging to increase originality than it was to increase the utility of creative solutions.

This supports the contention that problem solvers should be encouraged to 'sit with' and explore the problem, resisting the tendency to immediately start looking for solutions.

These findings suggest that the potential impact of these problem construction variables would be most effectively harnessed if a structured, specific methodology were followed to guide and steer the individual through the amendments to their default approach to problem solving. This is the intention behind the development of the normative framework.

Specific findings from this experiment will be used to inform the design of this framework, details of which are provided below.

18 WAYS IN WHICH EXPERIMENTAL FINDINGS HAVE BEEN INCORPORATED IN THE NORMATIVE FRAMEWORK

While in this study, narrow frames and an interrogative information search were found to be more conducive to creativity, it was concluded from the findings discussed above, particularly the finding that the most significant improvement in creativity was found under the Broad Interrogative condition, that the scope of the

interrogative information search should initially be broad.

Thereafter, once concepts related to the broad scope of the problem have been unpacked, narrow frames should be formulated to address combinations of concepts. Narrow frames would therefore be informed by an extended model of the problem.

This finding has theoretical implications as well as practical implications. By using a broad frame as the basis of the information search and a series of narrow frames as the basis for ideation, it is proposed that the potential advantages of both broad and narrow frames could be leveraged.

While the original intention in conceptualising the interrogative information search was for questions to emerge directly from information encountered as previous questions were answered, another finding from the qualitative analysis of the questions raised by participants in their interrogative information search, was that instructions to conduct the information search in this way were not effectively followed. This points to the need for a framework of questions to be used as prompts. This framework should be used to guide problem solvers in the practice of asking questions off the back of incoming information or responses, such that the comprehension and appreciation of the problem space is extended and deepened.

19 RECOMMENDATIONS FOR FUTURE RESEARCH

As the aim of this study was to explore how the concentrated curiosity model might affect the creativity of employees who are already required to exercise creativity in solving complex organisational problems, the case site for this study was selected due to the organisation being recognized as particularly innovative. Furthermore, participants in the experiment were senior employees who are expected to come up with novel solutions to complex problems. While this enabled the study to explore the factors that might enhance creative problem solving off an already high base, the challenge of getting sufficient numbers of senior employees to volunteer to spend two and a half hours in the experiment, resulted in a restricted sample size that provided limited power for statistical analysis. It is recommended that additional studies should be conducted amongst a population such as students, where recruitment is not as challenging, such that a larger sample may be recruited. In interpreting results from such a study however, caution may need to be exercised in extrapolating findings to the organisational context.

Findings that suggest that the narrow problem frames should be formulated after, rather than before the interrogative information search, have been used to inform the development of the normative framework, but as discussed in Section 5.2.2 of Paper 1, opinions differ regarding the optimal point at which constraints should be introduced in the problem construction process (Rosso, 2104). Further research is recommended to explore this question.

A qualitative study would also be useful to explore perceptions of the experience of problem solving using different combinations of the two variables of frame breadth and search type. Qualitative research could also be particularly useful in exploring shifts in cognitive flexibility, cognitive persistence, complexity of mental models and intrinsic motivation under the different conditions.

While in this study, changes in these four variables were measured by administering a self-assessment questionnaire, it would also be interesting to compare levels of cognitive flexibility, cognitive persistence, complexity of mental models and intrinsic motivation as measured by tests conducted before and after application of the experimental conditions.

A neuroscientific assessment of these four variables would also be an interesting approach. It would be especially valuable to explore the role of the interrogative information search from a neuroscientific perspective to ascertain how the continual and iterative questioning process may affect neurological activity.

The finding that creativity improves with the increase in complexity of the mental model of the problem provides another interesting point of departure for future research. In particular, it would be useful to explore alternative ways of sourcing additional inputs to the mental model and optimal representations of such mental models. While, for the purpose of this study, a visual representation has been employed in the form of a concept map, it would be interesting to explore both alternative visual representations and perhaps other more interactive approaches that could be used to capture and access the representation of the problem space.

PAPER 3: DEVELOPMENT OF A NORMATIVE FRAMEWORK

20 METHODOLOGY FOR DEVELOPING AND REFINING THE NORMATIVE FRAMEWORK

The third paper of this thesis develops a normative framework which provides practical guidelines for the implementation of the concentrated curiosity model. The development of this framework is based on the principles expressed in the theory that informed the design of the concentrated curiosity model, as well as insights from the experiment to test the model. Design principles from the theory are described in Section 21 and inputs from experimental findings are described in Section 22 below.

This paper initially develops a first draft framework for the interrogative information search based on these design principles, following which in-depth interviews are conducted with six problem solvers who needed to generate creative solutions, to get input on the relevance of this framework to their problems. The methodology used in these interviews is outlined in Section 23 and the outcomes of these interviews and their application in refining the framework are described in Section 24. The resultant iterations of the interrogative information search framework are included in Appendix C.

The normative framework also includes guidelines as to how a series of narrow problem frames are to be formulated based on the outcomes of the interrogative information search (See Section 21.2). While the approach to problem framing is not specifically tested in the interviews conducted as part of this study, which might be seen as a limitation, some insights are gleaned from the interviews that are then used to add to and refine problem framing guidelines (see Section 25.3). The value and relevance of these problem framing guidelines are then evaluated in the subsequent action research study documented in Paper 4.

21 DESIGN PRINCIPLES OF THE NORMATIVE FRAMEWORK

The aim of the normative framework is to translate the theoretical framework developed in Paper 1 of this thesis, into a practical approach to problem construction. According to the theory described, this normative framework should assist in the development of a rich, fluid, networked concept map that can be used to formulate narrow problem frames. These narrow frames should encapsulate sub-sets of the original problem that enable interrogation of the problem from different perspectives.

PAPER 3

As described in Section 6.5.3 in Paper 1, the development of such a concept map requires breaking the problem down into detailed concepts and identifying relationships between these concepts.

The approach prescribed here is to produce such a concept map by conducting a structured interrogative information search, following which a series of narrow problem frames are to be formulated by combining selected concepts or clusters of concepts. While findings from the literature that have been used to inform the development of the theoretical framework are described in detail in Paper 1, an article which summarises reasons for failures in creative problem solving (Mumford et al., 2020) has been used as a 'checklist' to ensure that, as far as possible, this normative framework addresses key issues highlighted by the meta-research of these authors.

A summary of the factors identified in this article, and the way in which this normative framework has been designed to address them, is provided in Table 21 below.

Table 21

Design principles of normative framework that address factors responsible for creative failures

Factors responsible for creative failures (Mumford et al., 2020)	Design principles to address these factors in normative framework
NATURE OF THE PROBLEM	
1. <u>Recognizing creative problems</u> The potential benefits or need for creative solutions to the problem may not be recognised.	Problem identification is not addressed in the normative framework
2. <u>Understanding the problem</u> Problem solvers may not actively search for and analyse novel aspects of the problem	The interrogative information search provides a detailed framework for actively searching for new information about the problem and assessing the ways in which it relates to other information about the problem
3. <u>Problem definition</u> Structure is not imposed on complex, ill-defined problems.	The interrogative information search is used to develop a structured concept map that categorises information about the problem and provides a visual depiction of the structure of the problem

Factors responsible for creative failures (Mumford et al., 2020)	Design principles to address these factors in normative framework
4. <u>Constraints imposed</u> Too few, too many, or the wrong kinds of constraints are imposed in the problem definition 5. <u>Simplification</u> Problems may be over simplified, such that important concepts and relationships between them are not identified. This undermines activities such as conceptual combination.	In composite problem framing, specific rules are imposed as to how concepts are to be combined, and resultant problem frames have a narrowly defined scope. The interrogative information search is designed so as to extend both the breadth and depth of the conceptual map of the problem. Relationships between concepts are also visually depicted on the resultant concept map. Concepts are also prioritised by flagging them on the concept map.
PROBLEM SOLVING CAPACITIES 6. <u>Domain expertise</u> Well organised mental models of the problem must integrate both case-based and conceptual sources of knowledge about the problem 7. <u>Monitoring and management of errors</u> Errors emerge from “freewheeling efforts” at creative problem solving. Analysis and criticism are required to scan for and resolve errors.	The interrogative information search framework is specifically designed to elicit a detailed conceptual explanation of the problem and integrate this with problem solvers’ experience in observing or managing comparable (analogical) problems. The process of working through the normative framework is based on a defined structure and requires a high level of rigour and attention to detail. By actively encouraging questioning, the interrogative information search is designed to highlight aspects of the problem that are unknown and facilitate debate.

Factors responsible for creative failures (Mumford et al., 2020)	Design principles to address these factors in normative framework
8. <u>Creative process execution</u> The following eight processes must be effectively and appropriately executed: a) problem definition or problem construction, (b) information gathering, (c) concept selection, (d) conceptual combination, (e) idea generation, (f) idea evaluation, (g) implementation planning, and (h) solution monitoring. 9. <u>Cross-process strategies</u> Strategies that organise how problem solvers work with knowledge, need to be conducted. Specifically, these include causal analysis, constraint analysis and opportunistic exploration	The normative framework is based on a process rather than a person centred approach (see Section 4.2 of Paper 1) and, as such, is specifically designed to provide a step-by-step approach to problem construction, information gathering and concept selection as an input into conceptual combination through composite framing. While problem construction is the focus of the theoretical framework developed in Paper 1, processes have also been developed to assist with idea generation (in the form of the DREAM TEAM), idea evaluation using an evaluation matrix, and implementation planning through the provision of guidelines. Solution monitoring is not addressed here. Causal analysis, specifically using a systems perspective, is addressed in the interrogative information search. Constraint analysis is conducted by identifying 'Obstacles'. Opportunistic exploration, which involves scanning the environment in light of goals (Mumford, Schultz, & Van Doorn, 2001), is conducted by identifying 'Contextual factors' after specifying 'Desired Outcomes' in the interrogative information search framework.
CONTEXT OF PROBLEM SOLVING 10. <u>Structuring the work</u> For creative solutions to be effectively implemented, the work environment must be well structured	This factor is beyond the scope of the normative framework

Factors responsible for creative failures (Mumford et al., 2020)	Design principles to address these factors in normative framework
11. <u>Information access</u> Information should be accessed from a variety of sources, including team members, and problem solvers must process and analyse information in novel ways.	The interrogative information search is specifically designed to address this. Collaboration with colleagues across the organisation, as well as external stakeholders, is required to populate the concept map. Categorising information and identifying relationships between concepts forms part of the analysis. Composite framing also requires viewing the concepts from different perspectives by placing them in relation to other concepts.
12. <u>Investment</u> Problem solvers should be fully invested in the creative problem solving process such that they devote the necessary time and resources	The process of conducting the interrogative information search and composite framing is time consuming, such that problem solvers are required to dedicate significant time to working through the process. As the normative framework contains detailed questions and guidelines, working through the framework also demands a high level of cognitive persistence. (See Section 33.3 in Paper 4).

Source: Mumford et al. (2020)

The design principles underpinning the approach to information search and problem framing that are informed by the concentrated curiosity theoretical framework, are described below.

21.1 Design principles underpinning the interrogative information search framework

A key principle of the interrogative information search is to pose questions based on the information gathered in response to previous questions. This implies that ideally, the problem solver should be required to design their own questions tailored to address the information they have accessed. However, findings from the experiment clearly indicated that instructions to this effect were not effectively executed (see Section 16.6 of Paper 2), suggesting direct guidance through this process is required.

Having reviewed the literature, while high level frameworks, often expressed in acronyms, were found to prompt investigation into different aspects of a problem, no comprehensive yet specific sets of questions were found to explore detailed concepts or relationships within these categories. The most comprehensive set of questions identified was the Phoenix checklist (Michalko, 1991), yet these questions are not designed to facilitate the structured, rigorous level of enquiry deemed necessary.

In designing the interrogative information search framework, two fundamental challenges had to be addressed. Firstly, to implement the principle that the interrogative search process should be iterative, the framework needed to allow for sufficient flexibility such that questions posed would be informed by information gleaned. Secondly, questions and prompts needed to be sufficiently generic to address the attributes of different problems, while at the same time being sufficiently detailed so as to actively provoke the consideration of alternative perspectives.

The in-depth interviews conducted with the six problem solvers who were asked to apply the interrogative information search framework to complex, unbounded problems relevant to their work, served to refine the structure of, and questions within the framework to meet these dual requirements of broad relevance and provocative enquiry.

The set of detailed questions and probes were formulated to explore certain categories of information about the problem. Both the categories and questions themselves were iteratively revised, as can be seen in Appendix C. In the final draft, the categories of questions included Desired Outcomes, Obstacles, Enablers, Contextual Factors and Analogical or Comparable Problems.

Specific principles upon which the formulation of questions were based, are described below.

21.1.1 Interrogative information search based on broad problem frame

The interrogative information search was developed to provide questions that guide problem solvers to sequentially break down, expand on and explore different aspects of the problem in depth, with the aim of both extending and deepening the conceptualisation of the problem.

As discussed in Section 4.3 of Paper 1, in practice, the stages of the creative problem solving process will invariably not follow a straight line process (Hindle, 2012; Runco & Nemiro, 1994). However, the normative framework has been informed by the experimental findings that suggest it is optimal to initially adopt a broad problem frame that enables a broad based interrogative information search (see Section 18 in Paper 2). Thereafter, subsequent information searches may be more narrowly focussed, such that the benefits of both a broad and a deep search may be harnessed. This approach aligns with findings that ideas are more efficiently generated when problem solvers start with a broad problem frame and then adopt a purposeful strategy to break the problem down into sub-problems (Harms et al., 2018; Ho, 2001). It also aligns with the opinions of those who support the active incorporation of structure and constraints in the creative process (Finke, Ward & Smith, 1992).

21.1.2 Autonomy in use of the framework

Categories of questions follow on from each other, although it is possible to cycle back to questions from a previous category based on answers or insights that emerge in the process. Similarly, questions in each category are designed to further probe answers from previous questions, but the sequence may be fluid if preferred by the problem solver. Problem solvers should also select the questions that are most meaningful to them. There should therefore be autonomy in how the process is followed.

This autonomy in the use of the interrogative information search is an essential aspect of the framework, as was noted in Section 6.6.1 of Paper 1, which highlights findings that autonomy in selecting questions considered interesting to the individual, is likely to deepen curiosity and interest (Cordova & Lepper, 1996; Kashdan & Fincham, 2004; Ryan & Deci, 2000).

21.1.3 Rationale for structure and questions in the interrogative information search

The structure of and questions in the interrogative information search framework have been formulated to achieve the specific objectives described below.

A Developing alternative perspectives on the problem

A key objective of the interrogative information search is to enable the problem solver to see the problem in new ways and reveal new and surprising insights. An approach that has been used to meet this objective is to ask questions that necessitate the search for different types of information by posing questions related to different aspects of the problem.

Accessing different types of information that highlight different attributes of a problem has also been found to facilitate more conceptual thinking and superior problem formulations, as searching for information related to specific exemplars limits thinking to familiar constellations of concepts (Ward et al., 2004).

The interrogative information search has therefore been structured to direct attention sequentially to different aspects of the problem.

Another approach that has been used to explore alternative perspectives and generate doubt about the current understanding of the problem, is to ask challenging questions that compel a search for information that is unlikely to be readily available. When asked a question about the problem that is not easily answered, the dominant tendency of problem solvers may be to dismiss this question as irrelevant, but if encouraged to pursue it, they may actively engage with and explore this new avenue of enquiry (Locke et al., 2008).

B Framing questions to facilitate both broad and deep interrogation

The widely applicable, generic set of questions of ‘who, what, where, when, why and how’ encourages a broad consideration of relevant concepts, such that use of this framework of questions has been shown to increase the variety as well as the originality of problem statements generated (Vernon & Hocking, 2014). This underscores the potential value of using guidelines and prompts in the information search. A key consideration, however, is that the relatively superficial prompts offered by these six questions are unlikely to facilitate the level of specificity and rigour required to nudge problem solvers into exploring the uncharted territory of different facets of their problems. Findings from the experiment described in Paper 2 clearly indicated that problem solvers typically ask questions that are limited in both range and depth, tending to extend a single line of questioning into potential solutions rather than seek a better understanding of the problem. (See Sections 15 and 16.6 of Paper 2).

Especially with more complex problems which, by definition, are the problems to which creative problem solving is applicable, problem solvers therefore tend to examine only a small proportion of the relevant scope and depth of information (Lee, Herr, Kardes, & Kim, 1999). Consequently, it was considered necessary to provide more direction than is offered by the generic questions of ‘who, what, where, when, why and how’, as it is argued that unless the problem solver is both skilled in and motivated to extend and deepen the information search into unfamiliar areas, questions such as these six are unlikely to prompt a sufficiently wide ranging or deeply probing exploration of the problem to reveal an adequate range of alternative perspectives.

The interrogative information search framework therefore poses questions designed to extend the breadth and depth of understanding. The questions comprising this framework are a fundamental element of this normative framework in order to facilitate the rigour required in exploring the problem space. While the process of collating inputs in order to ultimately represent the problem in a conceptual map may resemble a method such as the strategic options development and analysis method (SODA) (Mingers & Rosenhead, 2004), the questions used in the interrogative information search require a more structured interrogation of the problem.

C Eliciting of diversive and specific curiosity

Questions are designed to elicit both diversive curiosity to expand the conceptualisation of the problem space and specific curiosity to probe particular aspects in depth, as both diversive and specific curiosity have been found to be predictive of curiosity (Hagtvedt et al., 2019; Hardy et al., 2017).

Specific questions are also posed to highlight the unexplained aspects of the problem, such as by asking what information is missing. Such questions have been included to act as triggers of curiosity (Loewenstein, 1994). Given that curiosity also requires regulation of attention to focus on these triggers (Kashdan et al., 2004; Kashdan et al., 2009), higher level questions are also unpacked into more specific, underlying questions. If the higher level questions are glossed over, the lower level questions are designed to channel attention to specific aspects of the higher level question, thereby creating multiple opportunities to recapture lapsed attention. A further requirement of curiosity is exploratory behaviour (Kashdan et al., 2018) and as the interrogative information search incorporates the search for answers to questions posed, as well as an exploration to identify potential additional questions, exploratory behaviour is therefore integrated in the process.

D Facilitation of abstract and conceptual thinking

Questions have also been included in the framework to facilitate more abstract thinking about the problem. To encourage more abstract conceptualisations of a creative thinking task to describe an alien, Ward et al. (2004) gave their research subjects instructions to consider characteristics of the new environment and come up with ideas for aliens that might be well suited to these conditions. This had the anticipated result of facilitating more creative ideas. Extrapolating from these instructions, questions have been included in the framework for the interrogative information search which encourage problem solvers to consider features of the end state rather than aspects of the problem. Examples of such questions include those related to benefits of the ideal end state, as well as consideration of contextual factors such as the anticipated impact of time. Questions such as these have been formulated to encourage higher level, more abstract thinking to draw the problem solver into accessing different types of information, and especially information that will not draw on exemplars of the current state (Ward et al., 2004).

It should be noted that while concepts are cognitive elements that act as the building blocks of more complex thoughts, this does not imply that concepts are so fundamental and primary that they are not constructed out of other concepts (Goldstone, Kersten, & Carvalho, 2013). Therefore while the interrogative information search has been designed to reveal and express the underlying concepts and relations between them, it is not a requirement that the resulting concept map should include only the most fundamental of concepts. While some questions have been designed to probe more primary concepts, the concept map that emerges from the interrogative information search is likely to be a mix of simpler and more complex concepts. Questions have therefore been posed to probe both the elements within a particular concept as well as the higher level concept of which they may be a part.

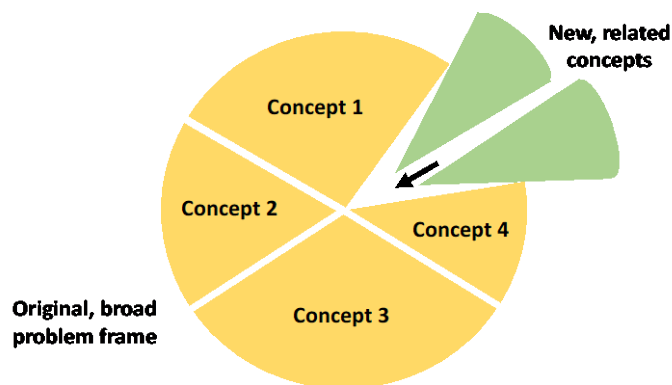
E Use of sequential questioning to building depth and breadth of understanding

As mentioned in Section 21.1.2 above, the problem solver may use the interrogative information search framework in a flexible manner, such as, for example, when questions posed prompt the problem solver to go back to questions previously addressed in order to deepen and expand the range of information sought in response to these questions. However, the aim of the interrogative information search framework is to create forward momentum in both broadening and deepening understanding of the problem. Different categories of questions have therefore been formulated to sequentially build understanding of different perspectives on the problem.

The intention of asking more incisive questions to probe responses is also to build both the depth and breadth of understanding. While breaking concepts down into component parts builds depth of understanding by exploring concepts in greater detail, paradoxically, thinking smaller may result in extending the scope of understanding too, as the identification of additional concepts could expand the problem space. This idea is illustrated in Figure 17 below.

Figure 16

How probing details may expand scope as well as depth of understanding



F Identification of relationships

A networked concept map that is most effective in creative problem solving requires not only the identification of concepts but the relationships between them (Kokotovich, 2008). In addition to the layout of the interrogative information search framework, which expresses relationships between concepts, specific questions are also included to probe relationships between concepts.

Questions about causal relationships, particularly with respect to barriers to achieving desired outcomes, have also been posed, as causal analysis is especially useful in supporting creative problem solving (Hester, et al., 2012; Mumford et al., 2020).

Problem solvers are also prompted to represent causal relationships in a causal loop diagram to develop their appreciation of the systemic nature of relationships. The documentation of the positive and reinforcing feedback loops that can be found in all systems provide a visual depiction of systemic challenges that are useful not only for understanding a system but for helping to identify and then address emergent challenges (Mingers & White, 2010; Senge, 1990; Tip, 2011). Generic patterns of these feedback loops may reveal resultant challenges that emerge from particular combinations of positive and reinforcing loops – referred to by Senge (1990) as systems archetypes. While building computer simulations of these systems is often conducted in the field of systems dynamics, it is common that these diagrams are also simply used to facilitate a systems perspective on the problem, thereby deepening understanding (Mingers & White, 2010).

G Questions to highlight priorities

After questions in each category have been addressed, a single question has been posed in each category regarding which of the points raised may be most relevant. These questions have been included to counteract the potential for the concept map to be overly complex. While a detailed concept map is supportive of creativity, it is important that high priority issues are highlighted such that the map can also be used to provide a view of the most critical concepts (Mumford et al., 2020). For the purposes of the development of this concept map, it is important that the detail is retained, but prioritising issues may assist in focusing attention, especially for the purposes of using the concept map as the basis for problem framing.

21.1.4 Development of a concept map based on responses to the interrogative information search framework

Responses to the questions in the interrogative information search framework should be captured in the same format as the framework. Given that questions in the interrogative information search framework are designed to explore both underlying and overarching concepts, rather than simply situationally bound responses, the outcome will be a visual representation of concepts and relationships between them, which has been shown to support creative problem solving (Hunter et al., 2006; Oxman, 2004; Ward et al., 2004). The resultant concept map should be both complex, due to the level and scope of detail and the depiction of relationships, as well as structured, due to the categorisation of concepts according to the categories of questions posed.

The hierarchical structure of the interrogative information search framework should be maintained in the resultant concept map, contrary to the view expressed by Kokotovich (2008) that a non-hierarchical concept map is preferable, due to its being more complex, as potentially significant benefits may be derived from a structured approach to the visual representation (De Dreu et al., 2012; Sagiv et al., 2010).

Furthermore, Mumford et al. (2020) found that while complexity is beneficial, excessive complexity has a detrimental effect on creativity. It is proposed that the organising principles of the categorisation of questions should support the problem solver to navigate the complexity of emerging concepts such that the level of complexity in the map of responses is optimal rather than overwhelming.

As per the interrogative information search framework which is used to generate the concept map, concepts are therefore to be grouped visually in themes, adopting the use of colour coding, as recommended by Kokotovich (2008). Such categorisation of concepts into similar themes has been shown to result in the generation of more ideas (Deuja et al., 2014).

21.2 Design principles informing composite framing: constructing narrow problem frames by combining concepts

The concept map derived from the interrogative information search framework is used to formulate a series of narrow problem frames. Using the concept map as the basis for identifying problem frames should allow the problem solver to see the relationships between these sub-problems and appreciate the broader context of the problem, thereby mitigating the risk of fixation (Rietzschel et al., 2006).

The guidelines described below are to be employed in the problem framing process. Problem solvers will be guided to combine different groupings of concepts and formulate narrow problem frames that incorporate the most important concepts they have identified, drawing on their responses to the last question in each section which asks them to highlight the most important concepts that have emerged. This approach is designed to purposefully implement the principle of conceptual combination. (See Section 6.5 of Paper 1)

A set of narrow problem frames will be formulated on this basis. Each concept may be included in different groupings and therefore different problem frames.

This approach, for which the term “composite framing”, has been coined, has been designed so as to facilitate fluidity in the way the concept map is seen and used.

21.2.1 Autonomy in selecting constraints to narrow the focus of problem frames

Problem solvers will be required to construct their own narrowly defined problem statements, which creates the opportunity for the individual to voluntarily impose their own sets of constraints. This autonomy in defining the parameters of the problem frame is important as constraints have been found to be particularly useful when they are self imposed (Herrmann et al., 2018).

Given that a narrow problem frame offers fewer readily apparent potential solutions, in order to generate solutions, the problem solver will be required to apply a high degree of executive control and deliberate attention to explore the limited problem space. It is therefore proposed that the narrowly focused, composite problem frames that emerge from this suggested approach will engender cognitive persistence, as the level of focus required will demand constant deliberative effort to generate ideas (De Dreu et al., 2008; Nijstad et al., 2010). Such structured, focused exploration is then likely to deliver more creative solutions, as original solutions are typically generated after the more readily available ones that have been identified, are discarded (De Dreu et al., 2012).

21.2.2 Problems framed as open ended questions

While constraints are applied in composite problem frames, by virtue of the narrow scope and rules employed in composite framing, divergent thinking within the resultant specific focus areas should be encouraged. Problem frames should therefore be phrased as open ended questions so as not to dictate specific approaches to addressing them (Gryskiewicz & Taylor, 2003).

21.2.3 Narrow problem frames to be addressed sequentially

In the ideation phase, the problem solver will focus on each of these narrow, composite problem frames sequentially, as described in Section 6.7 of Paper 1. Solutions for each problem frame should be exhausted prior to focussing on the next, as using sequential narrow frames has been shown to result in the generation of more ideas than when the sub-problems are addressed simultaneously (Coskun et al., 2000; Dennis et al., 1996). A related finding is that category switching is less efficient than focusing on a single category at a time (Deuja et al., 2014). It may then be possible to use solutions generated by focussing on prior frames when considering latter frames in the sequence.

22 EXPERIMENTAL FINDINGS THAT HAVE INFORMED THE PRACTITIONER FRAMEWORK

In addition to drawing on the theory outlined in Paper 1, and the concentrated curiosity theoretical framework in particular, the normative framework has also been developed on the basis of the findings from the experimental study used to test the theory (see Paper 2). The ways in which findings from the experiment have informed the normative framework are described below.

22.1 Effects of narrow versus broad problem framing

Although simple effects indicated that narrow problem frames are more conducive to creativity than broad problem frames, interaction effects did not support the hypothesis that a narrow problem frame is associated with higher levels of creativity. The problem construction found most effective in improving creativity was the combination of a broad frame with an interrogative search. (See Section 16.2 of Paper 2.)

Therefore, drawing on the input from the experimental findings, the approach adopted in this normative framework is to use a broad problem frame as the basis for the information search and subsequently to use narrow frames as the bases for ideation.

In the experiment, participants' high level of familiarity with the app may have led to the selected narrow problem frames being relatively familiar to the participants, such that these problem frames may not have challenged the participants to drill down into previously unconsidered aspects. It is therefore suggested that a more rigorous approach should be incorporated in the normative framework to facilitate the development of a more detailed networked concept map, as the externally imposed rigour of such a framework could result in a concept map that is less intuitive and therefore prevents the default approach to depend on habitual conceptualising of the problem.

22.2 Effects of the interrogative information search

While the effects of using an interrogative information search were not unequivocally supported by the experimental findings, an interrogative information search had a significant positive impact on those using a broad frame. This was true for both sub-dimensions of originality and utility (see Section 16.3 of Paper 2).

As mentioned in Section 15.3 of Paper 2 however, participants in the experiment did not follow the instructions of generating questions using the springboard, or stepping stone approach described to them, whereby each new piece of information that emerges is used as the basis for new questions. Findings also indicated that problem solvers tended to get distracted from focussing on the problem as their attention is drawn to exploring solutions. It is proposed that an underlying reason for this may be that participants require more structured facilitation to enable them to generate questions in this way. The normative framework was designed to address this.

23 RESEARCH METHODOLOGY TO REVIEW AND REFINE NORMATIVE FRAMEWORK

While the first draft of the normative framework is based on the theory and experimental findings described in Papers 1 and 2 respectively, the relevance and value of the interrogative information search framework have subsequently been reviewed by conducting a series of in-depth interviews with problem solvers from different disciplines.

The specific objectives of these interviews were as follows:

1. To determine whether the interrogative information search framework was relevant and applicable to a range of different problems
2. To gain insights that would assist in revising and refining the framework to optimise its relevance and value
3. To assess whether the interrogative information search framework achieves its intended dual purpose of
 - 3.1. Extending and deepening the understanding of the problem, and
 - 3.2. Facilitating the development of alternative perspectives on the problem

23.1 Sample selection

A purposive sampling strategy was used to identify and recruit six problem solvers who could review the framework's relevance to a range of different problems. Interviewees were identified from the fields of research, remuneration strategy consulting, management consulting, business development, manufacturing, and architecture, based on the assumption that practitioners in these fields habitually need to develop creative solutions to complex, unbounded problems. Short outlines of the professional backgrounds of these six problem solvers follow below.

Respondent 1 has been in the research industry for over 30 years. She is one of the independent researchers responsible for the Futurefact survey that monitors the significant media, social, political and economic attitudinal changes in South Africa. She also has extensive experience working in a variety of African markets. She provides technical oversight and data scrutiny as well as future-proofing for audience research on behalf of the media and advertising industries.

Respondent 2 (B.Sc., M.Sc., MBA (Stanford University)) has been a remuneration and organisational performance effectiveness consultant for more than 27 years. Prior to this he was in the computer industry for 22 years. He has more than 20 years' experience advising or serving on remuneration committees of government entities, NGOs, private and listed companies. He is currently a member of the remuneration and HR Committee of the Financial Intelligence Centre as well as pro-bono Board Director of the Overstrand Learning Hub NPC, PBO.

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Respondent 4 is an established business and strategy advisor with more than 20 years of experience at Strategy&, McKinsey& Co, Accenture and FeverTree Consulting. She has a cross industry focus that includes both the private and public sectors in Africa and Middle East. She has led the Diversity and Inclusion Africa portfolio for Strategy& and Partners in Performance for the last 5 years.

Respondent 5 is the engagement and business development manager for a loyalty programme. The position involves monitoring engagement across the various global markets and coordinating engagement projects and interventions for their global products. His previous role was the Campaign Manager for the company. This involved working with various stakeholders across various portfolios and businesses.

Respondent 6 (CA) SA has more than 20 years of experience in business start-up, business development and executive leadership across Africa. He held the position of Director at a financial services company for 11 years, during which time he provided unsecured credit to government employees in Africa. He served as Chairman and acting chairman of the board's credit committees and governance, risk and compliance committees within the group. He subsequently started an entrepreneurial venture by acquiring a manufacturing, sales and distribution business in the cosmetics industry.

Respondent 7 (Barch (Cum Laude)) is a self-employed architect with over 36 years of experience. During this time he has attended to over 550 projects, mostly of an upmarket residential nature, including single and multiple residential dwellings; townhouses; apartments; retirement living and hotels. His work has been published on a number of occasions.

Individuals were briefed before interviews and asked to identify problems which they were currently confronting that were complex and not well or easily defined, for which there was no one correct answer. The interrogative information search framework was then sent to them via email prior to the interview, to assist in orienting them to the nature of the interview.

23.2 Interview format

As in-depth interviews were required to apply the framework to their problems and enable full and detailed discussion of the framework and its relevance and value, face to face interviews were scheduled in two or three separate sessions, each with a duration of approximately 2 hours. Each interview was therefore conducted for a total of approximately 4 to 6 hours.

An open ended discussion guide, included in Appendix D , was used to ensure the relevant input was provided.

The interview included application of the interrogative information search framework to the particular problem they had elected to work through. Interviewees were taken through the framework by asking them to answer the questions in the framework in relation to their problem.

As per the discussion guide, throughout the interview process they were asked to provide their input on the relevance of the questions to their problem. Based on their input, suggestions were put to them regarding potential modifications, additions or exclusions, and they were asked for their feedback on whether these suggested changes would improve the relevance and value of the questions in helping them to improve their understanding of and/or gain new insights into their problem.

23.3 Analysis of information from interviews

Information from interviews was analysed to identify gaps in the range of relevant questions, duplications of questions, redundancies, required amendments to wording and alternative categorisation of questions. These findings were gleaned by analysing the direct feedback and the respondents' reporting on their experience of using the framework. Information was analysed to assess respondent's degree of comfort in navigating the framework, whether the sections followed on from each other intuitively, their difficulty in answering questions, which questions, if any, seemed to spark a new awareness or insight into the problem, which sections appeared most generative of new insights, and where more prompts were required.

Insights were incorporated into revisions of the framework, such that each interview yielded a new iteration of the interrogative information search framework. The iterations resulting each interview, are provided in Appendix C.

23.4 Limitations of the methodology

The number of interviews conducted may be viewed as a limitation, as the relevance of the normative framework was applied to only six types of problems. However, it may be argued that the limited number of interviews was counter-balanced by the in-depth nature of the interviews, which lasted for between four and six hours each. Thorough consideration was therefore given to the value and relevance of the framework to the diverse problems.

24 OUTCOMES OF INTERVIEWS

Responses to the questions posed at the end of each interview regarding the perceived value of the interrogative information search framework are provided below, based on notes taken during the interview to record responses.

24.1 Findings from Interview 1

The first respondent was an independent researcher. The problem addressed was how to develop a new business model for a syndicated survey.

Table 22

Amendments from interview 1

Shortcomings identified in Draft 1	Amendments made to Draft 1
The five categories of questions in the first draft did not build on each other effectively. The framework did not provide sufficient direction in guiding the problem solver through a process of deepening and extending insights into the problem.	The layout of the framework was redesigned, using a more linear, fishbone format to allow for a more directional design. Questions about Desired Outcomes were positioned on the right hand side as the end point and questions about Obstacles, Enablers, the Context and Analogical problems were positioned as inputs leading to the outcome.
The first category of questions, Clarifying Questions, included questions that were too broadly framed, with the result that the problem solver's responses were reiterating information about the problem that were already known to her, rather than challenging or extending her current conceptualisation of the problem.	The category of Clarifying Questions was excluded. Questions within this category were incorporated into other categories and reframed to be more specific. For example, the question "What other information do we need?" was incorporated in the section in Enablers that addressed insights about interested parties and obstacles.
A number of questions were posed in a manner that was too high level and could therefore ambiguous. One example was the question: "Are any elements mutually reinforcing?". While it was the intention to prompt thinking rather than elicit specific answers, the ambiguity could be used to allow problem solvers to choose a meaning that enabled them to provide a response related to information already familiar to them. Again therefore, the high level and ambiguous questions were not found to be sufficiently challenging.	Broad, high level questions were reworded or broken down into more detailed, specific questions. For example, the question "What are the causes?" was translated into a new category on Obstacles, within which a number of detailed questions were posed regarding obstacles and the relationships between them. Ambiguous questions were reworded and where necessary, sub-questions were included. For example, the question, "Are any elements mutually reinforcing" was moved to the Obstacles category and reframed as "How are these obstacles/ gaps related to each other?" with the sub-questions "Causal relationships?" and "Which exacerbate each other".

Shortcomings identified in Draft 1	Amendments made to Draft 1
While questions were required to both deepen and broaden understanding of the problem, classifying categories of questions into these two classes was not found to be effective, as different categories of questions could contain both questions to broaden and deepen understanding.	The classification that divided questions into those designed to deepen versus those designed to broaden understanding was removed, but all categories of questions were reviewed to ensure that both classes of questions had been incorporated into all categories.
It was found that the category of questions on Priorities did not function effectively as a category on its own, as it did not challenge the problem solver to consider particular dimensions to be prioritised.	The Priorities category was excluded and the sub-questions were incorporated into the category of questions on Obstacles.
There were too few detailed questions to challenge the current perspective.	Sub-questions were added to probe the current perspective in more detail.

24.1.1 Additional insights relating to Draft 1

1. A high level of facilitation was required to encourage the problem solver to consider alternative perspectives.
2. While the risk of having too many detailed questions is that they may not all be pertinent to the problem, the potential benefit of detailed questions is their ability to extend, deepen and challenge assumptions regarding the current understanding of the problem. This potential benefit was considered to be worth the risk that some questions might not be considered relevant.
3. In the facilitation, the problem solver should be encouraged to focus on and extend the line of enquiry regarding the most relevant questions.
4. All questions in the framework were found to be relevant to this problem.

24.1.2 Responses to reflection questions by Respondent 1

Reflection question 1: To what extent has answering these questions helped you to see your problem differently?

Response:

It has helped me to pinpoint issues and clarify the problem in a succinct way that makes it more manageable. I've also discovered new angles to explore and had some 'aha' moments. It has offered fresh thoughts on the problem. It has broadened my perspective and opened my mind to other options. I think we have been quite stuck in the way we've been looking at this.

Reflection question 2: Which (if any) questions or aspects of the framework helped you to think of your problem differently or find a new angle or perspective on your problem?

Response:

The questions about Obstacles and other potential interested parties (in Enablers) helped me to see that we could be fishing in a bigger pool of potential customers and that there are other ways of funding this survey outside of the traditional view that we hadn't considered before.

Reflection question 3: Did any new questions emerge for you as a result of your information search?

Response:

Yes – I am going to explore other funding models that have been used and other ways of marketing.

24.2 Findings from Interview 2

The second respondent was a strategy consultant and specialist in remuneration design. The problem that was discussed in the interview was how to define and measure the value contribution of an organisation responsible for compliance in financial services.

Table 23

Amendments from interview 2

Issues identified in Draft 2	Amendments made to Draft 2
More detailed questions were required.	A number of sub-questions and more detailed prompts were added.
Questions asking the problem solver to identify related concepts were not easily understood.	Questions were reworded to make them less theoretical and more easily comprehensible.
While a detailed causal analysis would be useful, adding this detail to the concept map would create undue complexity.	A question was added to prompt the development of a fishbone diagram, though the documentation of this causal analysis would not be included in the concept map.
Relationships need to be explored as a potential Enabler.	A branch to explore how relationships could be leveraged, was added to Enablers.
Trends amongst employees was identified as an additional Contextual question.	A question on trends amongst employees was added.

Issues identified in Draft 2	Amendments made to Draft 2
While identifying trends may expand appreciation of the context, problem solvers may need prompts to identify which present opportunities and which present threats.	Questions were added to probe which trends could be leveraged and which pose a threat.
Other stakeholders may also have an impact on the problem.	A Contextual question was added regarding the roles of other stakeholders.

24.2.1 *Additional insights relating to Draft 2*

1. While more detailed questions were added, the challenge of an overly complex concept map were highlighted and discussed. Questions were therefore added to each category of question to ask the problem solver to consider and highlight the most relevant points raised. These questions are to be considered after reviewing all questions in the category. As a result, questions on Priorities that were incorporated in Obstacles after the first interview were now incorporated into all categories.
2. As new perspectives or lines of enquiry that the problem solver finds particularly interesting are often highlighted during the discussion, it would also be useful to flag these points as they are raised.
3. While a principle of this methodology is that latter questions may spark additional responses to previous questions, this should be expressly highlighted. It was therefore decided that a set of guidelines on how to use the interrogative information search framework should be developed.
4. An overview of the whole process and categories of questions should be provided before delving into the detail within each category.
5. It would be useful to present the unfolding and iterative process in an app.
6. All questions in the framework were found to be relevant to this problem.

24.2.2 *Responses to reflection questions by Respondent 2*

Reflection question 1: To what extent has answering these questions helped you to see your problem differently?

Response:

It has allowed me to step back and consider the problem in a much broader context and see it differently. My brief is to develop a remuneration strategy to retain top technical staff, but the interrogative information search has shown me the need to consider a variety of other factors. I'd like to take the time to work through the interrogative information search framework diligently on my own.

Reflection question 2: Which (if any) questions or aspects of the framework helped you to think of your problem differently or find a new angle or perspective on your problem?

Response:

I found the overall structure useful. I found it useful that it was broken down into broad categories of questions. The first section on Desired Outcomes was particularly useful as a sanity check as it helped me to structure my thinking and make sure that I'm focussing on the right things. The questions regarding the building blocks of obstacles were also useful. Contextual questions helped me to step back from the more immediate barriers and consider other issues. It also helped me to see how to reframe issues more constructively.

Reflection question 3: Did any new questions emerge for you as a result of your information search?

Response:

How can I structure my thinking and step out of my own experience (given that I know this organisation very well)? What resources could assist me? How do I deal with the leadership? I'm now thinking about that in more depth.

24.3 Findings from Interview 3

The third respondent was a Senior Executive of a global strategy consulting firm. The problem that was discussed in the interview was how to develop approaches to assist a client organisation, a manufacturer of a food product, to turn around their declining sales and improve their profit margins.

Table 24

Amendments from interview 3

Issues identified in Draft 3	Amendments made to Draft 3
More detail was required to assist in prioritising the needs of interested parties.	The question in the Desired Outcomes category on whose needs should be prioritised, was replaced with sub-questions about non-negotiables and trade-offs.
The wording of 'building blocks' of obstacles could be cumbersome.	The term 'building blocks' was replaced with 'components'.

Issues identified in Draft 3	Amendments made to Draft 3
A suggestion was made to change the order of sub-questions on prioritising obstacles, and a sub-question relating to dependencies was considered important.	The sub-question on which obstacles are critical was replaced with a last question on which obstacles need to be resolved before addressing others.
While the development of a fishbone diagram was considered useful, the potential for circular causality should be considered.	The prompt to develop a causal loop diagram (Tip, T., 2011) has replaced the prompt to develop a Fishbone Diagram. This also enabled the removal of the sub-question on which factors exacerbate each other.
The question on ways in which the status quo may be falling short of the desired outcome was not relevant for this problem.	This question was provisionally retained in order to re-assess its value in subsequent interviews.
In the section on Enablers, the question on additional information that may be needed was seen as particularly useful, and it was suggested this may be broken down into external and internal information.	To safeguard the generic relevance of this framework, the sub-questions added refer to the problem itself and the broader context.
Alternative technologies and processes should be considered as Enablers.	Questions on alternative technologies and processes were added.

24.3.1 Additional insights relating to Draft 3

1. It was discussed that if the framework were to be programmed in an interactive version such as an app, this would facilitate the problem solver's autonomy in navigating questions.
2. Types of obstacles could be classified as structural or behavioural, however the level of detail provided by the range of prompts in this version of the framework are likely to provoke a wider array of considerations than this alternative broad classification.
3. While wording of the current version incorporates options such as 'gaps' instead of 'obstacles' to ensure that the framework is relevant in framing questions about both problems to be addressed and situations to be optimised, this may not be necessary and will be reviewed in future interviews.

4. Contextual questions might be seen as an extension of questions on Obstacles and Enablers. However, after considering whether Contextual questions could be divided into these two categories, it was deemed appropriate to maintain the current structure, as firstly, certain questions, such as those related to trends, may not be classified as Obstacles or Enablers, and secondly, it is suggested that it may be appropriate to purposefully expand thinking to the broader context on all issues after allowing for focussed attention on immediate Obstacles and Enablers.
5. All questions in the framework, other than the question relating to ways in which the status quo may be falling short, were found to be relevant to this problem.

Reflection question 1: To what extent has answering these questions helped you to see your problem differently?

Response:

It gave me structured insights into an unstructured problem. It provides a framework to help research a problem in a structured way which is especially helpful when dealing with a complex problem.

Reflection question 2: Which (if any) questions or aspects of the framework helped you to think of your problem differently or find a new angle or perspective on your problem?

Response:

The questions about Analogical problems were useful in broadening my focus and opening up new perspectives.

Reflection question 3: Did any new questions emerge for you as a result of your information search?

Response:

As it is part of my job to frame problem statements, there were no new questions that came up for me, other than the need to consider additional sources of external data, but it helped me to see structure emerging from the questions.

24.4 Findings from Interview 4

The fourth respondent was a Business Development Manager. The problem addressed in the interview was to find ways to keep members engaged in a loyalty programme.

Table 25

Amendments from interview 4

Issues identified in Draft 4	Amendments made to Draft 4
While overt needs of stakeholders may easily come to mind, it is important to specifically probe covert needs.	Sub-questions on overt and covert needs were added.
Some duplication and the need to recategorize questions was noted within the Outcomes category.	The sub-question on trade-offs was deleted as this became a higher level sub-question pertaining to what interested parties want. The question on non-negotiables was also moved to this level.
Questions about what is known and not known about interested parties should not be addressed under Desired Outcomes, as the details are explored under Enablers.	Questions on what is known and unknown about stakeholders were deleted from the Desired Outcomes section.
Different parties may have needs that conflict with each other.	Two sub-questions were added to the question on trade-offs as there may be conflicting needs within and between parties.
Attitudes of stakeholders may also present obstacles.	A prompt related to attitudes of stakeholders was added to the question on types of Obstacles.
The question on ways in which Obstacles prevent Desired Outcomes was seen as redundant.	This question was removed.
The question on ways in which the status quo may be falling short of Desired Outcomes was considered thought provoking.	While the value of this question was under review, it was retained as it might be useful for problems of optimisation.
Under the Enablers category, insights might also be sought regarding challenges encountered.	‘Challenges’ was added to the prompt about the concerns that interested parties might have.

Issues identified in Draft 4	Amendments made to Draft 4
The question on additional sources based on available data was ambiguous.	The question was reworded to clarify that the intention is to question whether enrichment of current data may be valuable.
Communication was not being interrogated.	Questions on communication were added to questions on relationships.
The question on the roles of other stakeholders under Contextual questions may be redundant.	Based on input from further interviews, this question was flagged for potential exclusion.
Questions related to the role of time do not clearly express the intention to interrogate the potential role of seasonality.	Wording of questions related to the role of time were amended and some questions were combined.

24.4.1 Additional insights relating to Draft 4

1. In the same way that specification of Outcomes should be prompted for different stakeholder groups, Obstacles may need to be similarly prompted for different stakeholder groups. While this would be cumbersome to incorporate in a hard copy or static version of the interrogative information search framework, this may be programmed into an interactive version such as an app.
2. The role of the question regarding categories of obstacles, which was intended to encourage higher level conceptual thinking, drawing on the specific obstacles identified, should be explained as such. This may require an explanatory note in the programmed version of this framework. In the hard copy format, this question has been moved to a sub-question, which may assist in contextualising it and expressing its role.
3. It was noted that questions pertaining to money, materials/ inputs, processes, expertise and relationships, under the Enablers category, were framed as questions about potential solutions. These were reworded such that they explore aspects of the current state of the problem.
4. All questions in the framework were found to be relevant to this problem.

Reflection question 1: To what extent has answering these questions helped you to see your problem differently?

Response:

It gave me a few different ways to see the problem and afterwards I had a lot of ideas around it which were based on some of the questions answered. I found the technique of persistently asking different questions about different parts of the same problem gave a more holistic understanding of the problem.

Which (if any) questions helped you to think of your problem differently or find a new angle or perspective on your problem?

Response:

The measurement and segmentation questions helped me think of lead measures and interventions as someone starts to disengage. A good solution might be a disengagement survey as the member has a change in behaviour. This was a helpful insight. The Analogical questions stimulated creative ways of seeing the problem.

Reflection question 3: Did any new questions emerge for you as a result of your information search?

Response:

The one that came to mind that I was thinking of is what is a different paradigm or way of seeing the problem that you haven't thought of?

24.5 Findings from Interview 5

The fifth respondent was the owner of a factory producing cosmetics distributed via direct sales as well as retailers. The problem addressed in the interview was to find ways to improve cash flow.

Table 26

Amendments from interview 5

Issues identified in Draft 5	Amendments made to Draft 5
A distinction could be drawn between short term and long term needs of stakeholders	Sub-questions were added to this effect
Under Outcomes, the wording of 'overt' and 'covert' needs appeared to be unclear or ambiguous.	Wording was changed to 'direct' and 'indirect' needs.
Questions under Desired Outcomes that enquired about where goals like this were seen to have been achieved, were not questions about desired outcomes as such.	These questions were moved to the section on Analogical questions. Sub questions were also added to probe what could be learned from successes or failures.
Limited resources was identified as a key source of potential obstacles. The nature of resource limitations could be probed.	A probe was added regarding the most problematic resource shortages.

Issues identified in Draft 5	Amendments made to Draft 5
Obstacles may also be related to reputation or image	Reputational or image related obstacles were added as a prompt
Insights may be gleaned from past mistakes or mistakes of others	Questions to this effect were included in Analogical questions
Solutions that may have worked in the past may now not be optimal	A prompt about sub-optimal, albeit functional conditions was added under Obstacles.
The question about incentivisation needed to incorporate non-financial incentives.	A question was added to enquire about non-financial incentives. While this was under the category of 'money' in Enablers, this question flowed logically from the question about incentives.
The question on time required an additional prompt to unpack the role of time in the problem.	Questions were added about what was taking too long or not long enough.
The question on the roles of stakeholders was too broad and duplicated previous questions.	The question on the role of stakeholders was removed.
Questioning which elements of the problem could change over time required more focused probing.	This question was divided into two questions which asked specifically about which Obstacles and which Enablers could change over time.
Scanning for trends required more focussed probing.	Questions on emerging trends were divided into trends that could pose a threat and those which could be advantageous. The sub-questions on which trends pose a threat and which could be advantageous were then removed.
The term 'Analogical Questions' was not easily understood by most of those interviewed.	The term was amended to include the term 'Comparable problems'.

24.5.1 Additional insights relating to Draft 5

1. Questions about the most relevant points highlighted in each category were not sufficiently specific to enable identification of key concepts to be used in the formulation of composite problem frames. These were rephrased accordingly.
2. Given that it is unlikely that contextual factors could be purposefully changed, the high level contextual question about this was revised to enquire about what would happen if the context changed.
3. The format of the concept map was amended to better visually depict the iterative nature of the questions, with one section flowing from another
4. Questions for reflection which were linked directly to the main topics as floating questions were incorporated into each section to simplify the format.
5. All questions in the framework were found to be relevant to this problem.

24.6 Findings from Interview 6

The sixth respondent was a self-employed architect whose most recent project included the development of senior living apartments. The problem addressed in the interview was to find ways to attract younger people, from age 70 to buy these apartments.

Table 27

Amendments from interview 6

Issues identified in Draft 6	Amendments made to Draft 6
The initial problem frame identified was to optimise the offering, however, after answering the questions about Outcomes, Obstacles and Enablers, the problem frame was revised to address the question of how to attract people in their early 70's.	Implications for the process, rather than the content of the framework, are that asking the questions posed may assist in reframing the problem, rather than only building on the complexity of the mental model of the problem. The process for using the interrogative information search has therefore been modified to prompt potential reframes of the problem in the process of looking for information about the original problem frame.
It was observed that rather than immediately commencing with asking questions about the problem, it was valuable to have an initial broad discussion about the problem, after which the specific questions could be posed.	While the questions within the interrogative information search framework did not need to be amended, the issue identified had implications for the process and the way in which the interrogative information search framework is to be used.

24.6.1 Additional insights relating to Draft 6

1. In this, the final interview conducted in order to get input into the development the interrogative information search framework, all categories of questions and all questions within categories were considered relevant to the problem and no revisions to the content of questions and prompts within the framework were considered necessary. Visual enhancements were made however, such that Draft 7 has a cleaner format and includes the prompts to highlight priority issues with a red flag.
2. As with previous interviews, it was observed that active facilitation was required. It appears that familiarity with the problem and habitual ways of talking about the different aspects of it, result in a narrative that is not easily disrupted. Problem solvers therefore initially appear reluctant to segue into exploring the questions about the problem, but are receptive after repeated prompting.
3. All questions in the framework were found to be relevant to this problem.

Reflection question 1: To what extent has answering these questions helped you to see your problem differently?

Response:

It provided a structured, logical, rational approach that challenged me to think in far more detail about the problem.

Which (if any) questions helped you to think of your problem differently or find a new angle or perspective on your problem?

Response:

The breadth of the scope of questions that were then broken down into components was very useful in helping me to look at the problem differently. The question about other potential stakeholders was useful as it made me think of what we might have done and not done for them.

Reflection question 3: Did any new questions emerge for you as a result of your information search?

Response:

I discovered new things that I hadn't considered. As I am a rational thinker, this structured approach appeals to me. While my mind turns to solutions by default, analysis of the problem took me to places I hadn't thought of.

I would like to use this framework in an upcoming meeting with other stakeholders to help us to think about aspects and questions we haven't considered before.

25 OVERVIEW OF FINDINGS AND IMPLICATIONS FOR THE INTERROGATIVE INFORMATION SEARCH FRAMEWORK

25.1 Findings related to research objectives

Objectives of this stage of the research were defined in Section 23 as:

1. To determine whether the interrogative information search framework was relevant and applicable to a range of different problems
2. To gain insights that would assist in revising and refining the framework to optimise its relevance and value
3. To assess whether the interrogative information search framework achieves its intended dual purpose of
 - 3.1. Extending and deepening the understanding of the problem, and
 - 3.2. Facilitating the development of alternative perspectives on the problem

Findings related to the first objective confirmed that the framework of questions was applicable to the range of problems presented by the six problem solvers. Interviewees from different disciplines who applied the framework to a diverse range of problems confirmed that the questions had broad relevance yet probed their problems in depth.

Fulfilment of the second objective was implied by the finding that the sixth and final interviewee did not indicate a need to revise any of the questions. This further reinforced the conclusion that the first objective of broad relevance to a diverse range of problems had been met, by confirming that the previous iterations based on the results of the five interviews conducted to that point had refined and developed the set of questions such they were sufficiently relevant and generically applicable to a wide range of problems.

Feedback received from the six problem solvers, recorded in their responses to the three reflection questions posed at the end of the interviews, indicated that using the interrogative information search framework had both extended and deepened their understanding of their problem and had enabled them to develop alternative perspectives on their problems. Feedback received therefore confirmed that reflecting on these questions assisted problem solvers to see their problems in a different light. A related result was that new lines of questioning were pursued, such that problems were in some instances also reframed (see Section 24.6). Evidence of the perceived value of the framework in supporting effective problem construction was notably provided by the sixth problem solver who asked to use the framework in a scheduled meeting with stakeholders to discuss the problem, as he felt it would support them in their attempts to come up with alternative insights.

It appeared that a facet of the interrogative information search framework that was considered especially valuable was the structured approach to questioning which problem solvers reported useful in helping them to structure their understanding of their problem. This feedback supports the view proposed in Section 6.6 of Paper 1, that the use of a structured approach to the information search demands a level of rigour that results in an extended mental model of the problem and that structure plays a valuable role in creativity (see Section 5.2.2 of Paper 1). Reports by these interviewees about the value of the high level of structure in the interrogative information search framework also endorse the proposition that structure facilitates scanning for the unexpected (Goldenberg et al., 1999).

25.2 Implications of findings for the interrogative information search framework

Revisions to the different versions of the interrogative information search framework resulted in a simplified conceptual map that encapsulates a particular from from one category to the next, and contained more detailed prompts within each section. Questions were also revised to minimise ambiguity and certain questions were culled to avoid duplication.

Latter interviews pointed to fewer required modifications, suggesting that such modifications conducted as a result of input from earlier interviews enhanced the relevance and value of the framework when applied to other kinds of problems.

Overall, findings from interviews confirmed that the interrogative information search framework had broad relevance and indicated that applying the framework facilitated the development of a more complex and detailed mental model of the problem, as interviewees responded that they had indeed discovered new, previously undiscovered aspects to the problem.

It was concluded from the analysis of responses to interviews therefore, that the interrogative information search framework had been refined to the point where it could be tested in the subsequent action research study.

25.3 Implications of findings for problem framing

While it was not the aim of these interviews to test the effectiveness of the proposed approach to problem framing, insights that can be applied to problem framing were gleaned from the revisions to the interrogative information search framework. Given that the primary aim of the composite framing approach discussed above is to facilitate conceptual combination, discussions in interviews regarding potential problem frames that could emerge, indicated that there are particular combinations of concepts from different categories of questions that might prove fruitful.

Therefore while the problem solver is to be invited to use their own discretion in selecting and combining elements from the concept map of their problem, guidelines based on these insights regarding ways in which concepts can be combined, have been formulated. These are outlined in Step 5 of the overview of the normative framework in Section 26 below.

25.4 Implications of findings for the implementation process

Before getting into the detail of the questions, problem solvers tended to want to provide an overview of the problem (see Section 24.6). It would be valuable to allow for this open ended expression of the problem before getting into the specific questions in the interrogative information search framework.

Active facilitation was required in all interviews to probe issues and suggest potential responses, drawing both on industry and business related factors as well as past responses. In many instances where such facilitation proved useful, problem solvers had initially provided a relatively superficial response to the question in the framework, but after probing from the facilitator, offered an alternative response which they agreed provided fresh insights into the problem.

The process of developing a detailed concept map of the problem therefore requires the problem solver to be nudged into exploring and pondering unfamiliar considerations about the problem. This is not an unexpected finding, and in fact the resistance to thinking about the problem in a new way is a fundamental assumption that has informed the development of this interrogative information search framework (see Section 6.6.3 of Paper 1).

This need for active facilitation, which was endorsed by results of the action research (see Section 6.7.3 of Paper 4), confirms that problem solvers need external input that demands that they question their familiar conceptualisation of the problem. This points to the need for an approach and framework that requires the problem solver to apply rigour in reviewing their understanding of different aspects of their problem. The structured approach and detailed questions in the interrogative information search, as well as the composite framing approach, which is used to help the problem solver approach the problem from different perspectives, are designed to enable this.

The iterative nature of the interrogative information search requires the problem solver to continually extend their questioning of the conceptualisation of the problem and build on the concept map.

Without facilitation, the resultant complexity of the conceptual map could become overwhelming. The mechanism of highlighting the most significant concept in each branch of the concept map is designed to manage the complexity by enabling focus on priorities.

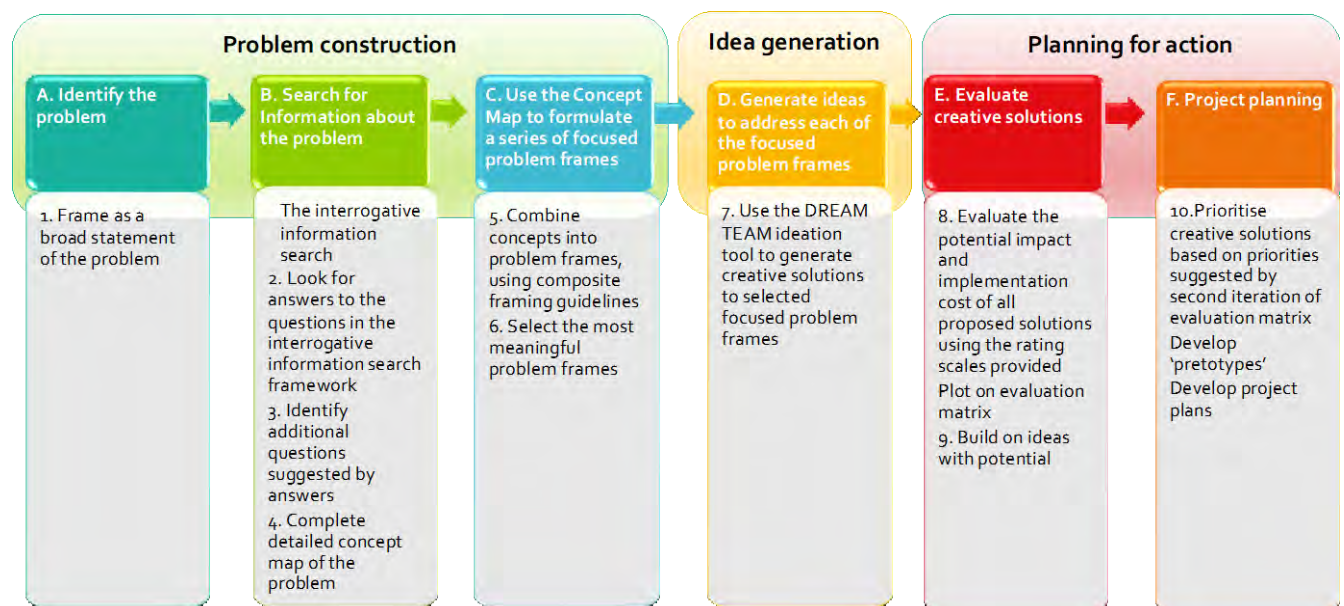
Applying composite framing, which involves selecting key concepts to be combined in problem frames may also assist the problem solver in managing complexity, as this enables them to home in on specific aspects of the concept map rather than having to address the map as a whole. As composite framing results in a series of narrow frames, the problem solver is prompted to view the problem through the lens of the different frames, encouraging cognitive flexibility.

26 OVERVIEW OF NORMATIVE FRAMEWORK

The normative framework that has been developed on the basis of the theoretical principles and research findings discussed above, is illustrated Figure 18 below.

Figure 17

Practitioner framework



Note: While the stages of 'idea generation' and 'planning for action' are not the focus of this thesis, approaches to these stages have also been developed to ensure that the normative framework developed here provides a comprehensive set of guidelines.

A. Identify the problem

Step 1: Develop initial broad problem frame

Initially, the problem should be framed using a broad problem statement. This broad view should be discussed to provide an overview of the problem (see Section 25.4).

B. Search for information about the problem

Step 2: Look for answers to questions in interrogative information search framework

Look for answers to questions posed in the final draft of the interrogative information search framework (see Draft 7 in Appendix C) using the following guidelines:

Guidelines for using the interrogative information search

1. Proceed through the sequence of answering questions regarding,
 - The Desired Outcomes
 - Obstacles
 - Enablers
 - The Context
 - Analogies/ Comparable problems
2. If pondering latter questions evokes thoughts on questions already considered, go back to these questions and provide the relevant responses. Then resume reflecting on questions as per the sequence.
3. Not all questions may be relevant, but if at first a question appears not to be relevant to the problem being addressed, attempt to probe whether this is the case before moving on to the next question.
4. Not all questions deserve equal attention for your problem. While some questions do need further consideration, even if at first they do not appear overly relevant, focus on answering the questions that you find most interesting and provocative.
5. Responses to certain questions may require further research. Not all questions need to be answered immediately.
6. Responses to questions should be documented in a concept map based on the same format as the interrogative information search framework.
7. When particularly useful insights are noted, they should be flagged as high priority concepts on the concept map.
8. In the process of developing the concept map, it may be noted that the initial broad problem statement needs to be reframed. In this case, a new concept map should be developed.

Step 3: Identify new questions

Identify additional questions that may emerge in the course of searching for and formulating answers to questions in the interrogative information search framework.

Step 4: Complete detailed concept map of the problem

The resultant concept map should be reviewed to ensure that it provides a complex model of the problem that includes

- relevant concepts
- relevant relationships
- flagging of priority concepts

C. Formulate series of focused problem frames

Step 5: Combine concepts into problem frames using composite framing guidelines

Composite framing guidelines constitute a practical approach to enable conceptual combination, drawing on priority concepts flagged in the concept map of the problem.

Composite framing guidelines

1. Combine concepts from Outcomes and Obstacles

Generic problem statement: *In what ways could this outcome be achieved by avoiding or overcoming this obstacle?*

2. Combine concepts from Outcomes & Enablers

Generic problem statement: *In what ways could this resource be used to address the needs of this stakeholder?*

3. Combine concepts from Outcomes & Context

Generic problem statement: *Given this contextual element, in what ways could this stakeholder's needs be addressed?*

4. Combine concepts from Outcomes & Analogies

Generic problem statement: *In what ways could we emulate how this outcome has been achieved by others in this analogical situation?*

5. Combine concepts from Obstacles & Enablers

Generic problem statement: *In what ways could this obstacle be addressed by drawing on this resource?*

6. Combine concepts from Obstacles & Context

Generic problem statement: *Given this contextual element, in what ways could this obstacle be addressed?*

7. Combine concepts from Obstacles & Analogies

Generic problem statement: *In what ways could learnings from this analogical situation be harnessed to overcome this obstacle?*

8. Combine concepts from Enablers & Context

Generic problem statement: *Given this contextual element, in what ways could this resource be better leveraged?*

9. Combine concepts from Enablers & Analogies

Generic problem statement: *In what ways could we emulate how this resource has been leveraged by others in this analogical situation?*

Step 6: Select the most meaningful frames

A series of problem frames should be selected from those generated and addressed sequentially by using an ideation technique to generate potential creative solutions to each problem frame.

D. Generate ideas to address each of the focussed problem frames

Step 7: Use DREAM TEAM ideation technique

For idea generation, the DREAM TEAM ideation technique has been employed. This technique was developed for the purposes of the experiment, and was found to be effective by participants. This approach was modelled on the SCAMPER ideation technique, in that it requires the problem solver to consider a series of alternative ways of addressing the problem (Eberle, 1996; Osborne, 1953). This series of mental operations is described by the acronym, DREAM TEAM, based on the first letter of the description of each operation. These operations are described in Figure 19 below.

Figure 18*DREAM TEAM ideation technique*

Diminish or Downscale Are there parts of the problem you can diminish or downscale?	Tailor Are there parts of the problem you can tailor to address specific needs/ purposes/ people?
Resourcing Could you consider alternative resources for managing the problem, such as by outsourcing or partnering with others?	Emulate Are there examples of how this challenge or similar challenges have been addressed by others that you can learn from and emulate?
Extract Are there aspects of the problem that can be extracted or eliminated?	Automate Is there a way you can harness or make better use of technology ?
Add Is there a new element you could add or introduce to combine with existing elements?	Make Magic What can be done to add a spark of something special ?
Magnify Could you magnify or exaggerate any aspect(s) ?	

E. Evaluate creative solutions***Step 8: Evaluate proposed solutions***

The potential impact and implementation cost of all proposed solutions generated in the ideation phase are to be evaluated using the following evaluation criteria and rating scales:

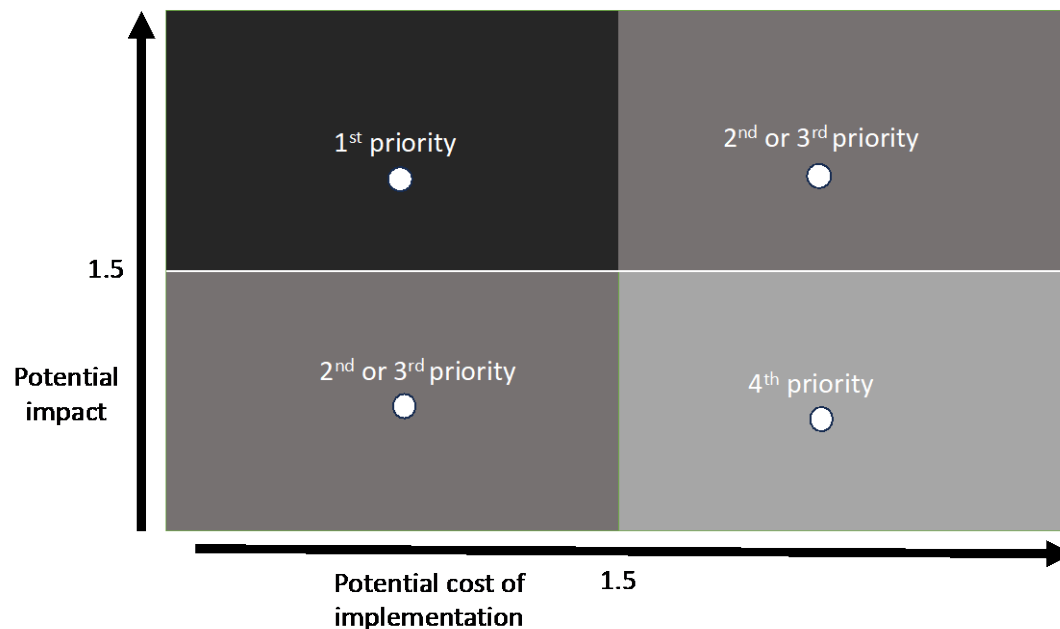
IMPACT EVALUATION CRITERIA	RATING (1 = Low/ 2 = Med/ 3 = High)
Extent to which priority issues are addressed	
Long term sustainability of impact	
Benefits to stakeholders	
Average Rating	

COST EVALUATION CRITERIA	RATING (1 = Low/ 2 = Med/ 3 = High)
Direct financial cost	
Resource intensity	
Time to implement	
Potential for disruption	
Average Rating	

Using the average ratings of Impact and Cost, proposed solutions should then be mapped onto the evaluation matrix in Figure 20 below.

Figure 19

Evaluation matrix for proposed creative solutions



Each solution's position on the evaluation matrix will inform whether they should be selected and further developed.

Step 9: Build on ideas with potential

Based on their position in the evaluation matrix, ideas should be selected for further development. Such development could take place by using the Six Thinking Hats to explore each idea's potential (De Bono, 1992). Once ideas have been further developed, they may be re-evaluated. The potential impact and costs can then be re-evaluated and plotting on the evaluation matrix may be revised.

F. Project planning

Step 10: Prioritise creative solutions, test through the use of 'pretotypes' and develop project plans

- Plan timing for implementation of priority ideas suggested by second iteration of evaluation matrix and rank according to urgency.
- Identify stakeholders who need to buy in to the idea and those responsible for implementation and ask for input to assist in scenario planning. Communicate benefits and share plans of alternative scenarios to gain commitment of key stakeholder groups (Seelig, 2015).

- Develop 'pretotype' in the form of a rough facsimile of the end product to test the viability of the concept before full scale development (Seelig, 2015).
- Develop detailed project plans delineating timelines, resource requirements and accountabilities.

27 RECOMMENDATIONS FOR FURTHER DEVELOPMENT

A number of respondents felt that programming the interrogative information search framework into an app would be valuable. It is the intention to review the potential to develop such an app once input from action research has been incorporated into the normative framework.

Furthermore, the use of artificial intelligence in such an app should be reviewed to explore whether it might offer the additional prompts and probing questions based on answers provided. If so, artificial intelligence may be used to support the level of rigour required in responding to questions in the interrogative information search framework.

PAPER 4: ACTION RESEARCH TO TEST & ENHANCE THE NORMATIVE FRAMEWORK

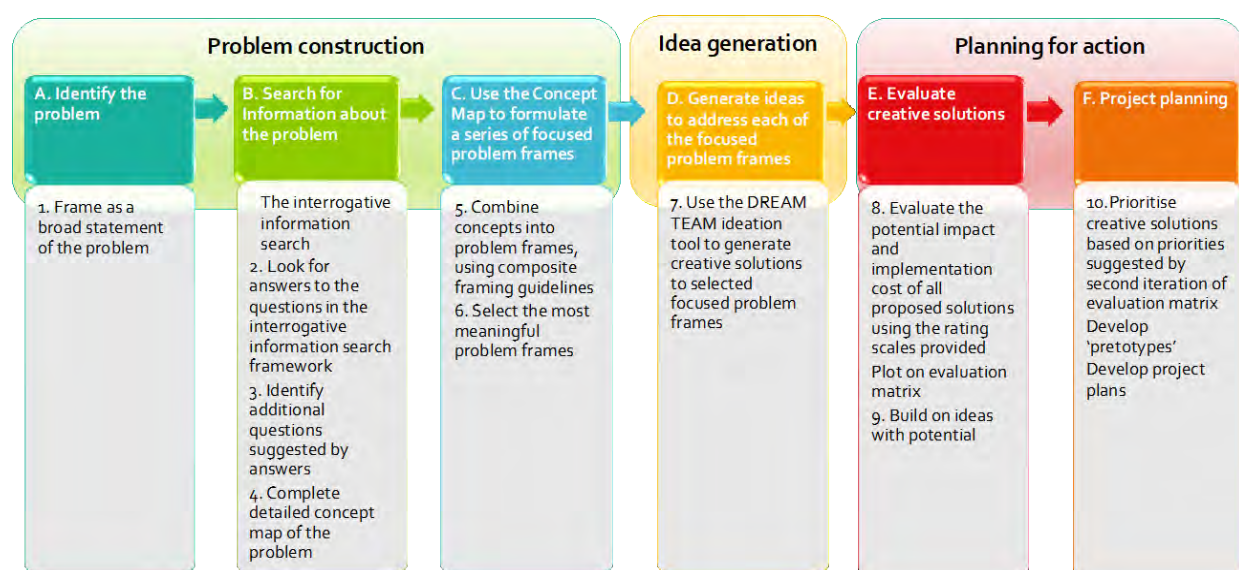
28 INTRODUCTION AND FRAMEWORK

Paper 4 employs action research to elicit feedback on the normative framework developed in Paper 3, which was designed to implement the model of problem construction developed in Paper 1 and tested experimentally in Paper 2. The purpose of this study is twofold. The first objective is to explore how the implementation of the normative framework is experienced and identify ways in which this framework could be refined to enhance its impact. The second objective is to serve as a second field test of the theoretical model.

The diagrammatic overview of the normative framework, which includes the second and third stages of idea generation and planning for action, is repeated from Paper 3 in Figure 21 below. While the stages of planning for action and idea generation are included for completeness, testing the effectiveness of the approach to these two stages was not within the scope of this action research study.

Figure 20

Practitioner framework



The research design, findings from this research and their application back into the normative framework are described here.

29 CONTRIBUTIONS OF THIS PAPER

With regard to the objective of serving as a second field test of the concentrated curiosity theoretical model, one of the ultimate aims of this paper is to make a theoretical contribution. The primary contribution of this paper however, is methodological, as the intention in developing this normative framework is to bridge the gap between theory and practice. It is argued in this thesis that there remains a distinct need for a structured, rigorous normative framework that draws on evidence based guidelines (Paulus, Dickson, Korde, Cohen-Meitar, & Carmeli, 2016; Paulus & Kenworthy, 2018; Vernon, Hocking, & Tyler, 2016). The primary aim of this paper is to meet this need.

30 RESEARCH METHODOLOGY FOR PAPER 4

30.1 Research design

The researcher selected action research to explore and enhance the effectiveness of the normative framework. The methodology of action research was well matched to meeting the research objective as it enabled the eliciting of nuanced responses to the experience of implementing the normative framework and was focused on practical as well as theoretical and conceptual outcomes (Bradbury & Reason, 2003). For this reason, action research has also been instrumental in the development of Soft Systems Methodology (SSM) (Checkland & Poulter, 2020). While some theorists hold that action research can be conducted with the researcher merely serving as an observer, the philosophical approach adopted for this study was that the researcher, who was also responsible for training on and facilitation of the normative framework, was by implication a participant in the study. Thus the term 'action research' is intended to embrace the approach of 'participative action research' (McNiff & Whitehead, 2011).

30.2 Case site, sampling methodology and unit of analysis

For the action research study, a number of requirements for the sample needed to be met. Firstly, it was necessary to have access to a group of employees responsible for solving a complex problem and importantly, they would need to be willing to commit to being available for four three-hour workshops. Participants also needed to agree to participating in a focus group after each workshop and to being interviewed in their personal capacity. In addition, they would need to complete a questionnaire regarding their experience.

A senior company representative of a large national courier company, granted permission for the study to be conducted within their organisation. A purposive sampling strategy was then used to identify the participants, based on the requirements mentioned above.

Participants were recruited into this study with the assistance of the senior company representative, who invited them to participate, based on their involvement in trying to solve a complex problem that they identified as a one they would like to address through creative problem solving. The group of five participants constituted five employees responsible for business improvement at the company. The increased competition in this industry over the last few years, especially since the COVID pandemic necessitated an increase in deliveries, had highlighted the need to review and improve their operating model. The job titles of the individuals in the group included Chief Information Officer, Business Improvement Manager, Group Financial Manager, Branch Accountant, and Business Improvement Engineer. The units of analysis were the group of five senior managers as well as the individuals who comprise this team.

As the framework is cognitively demanding, and in this study it was to be applied to a high level strategic challenge, it was appropriate that the individuals selected to participate were all senior professionals. In assessing the usability of this framework, it should be noted that findings may be more relevant to similarly senior employees.

30.3 Research procedure

This study involved running four workshops with the team of participants who implemented the normative framework using a phased approach. Workshops were scheduled to run for approximately 3 hours each, although some did run over time, with one extending to four hours. They were conducted around a meeting table at the Head Office. Slides used in facilitating these workshops are provided in Appendix E.

As action research is based on a cyclical process (Ozanne & Saatcioglu, 2008) this study included four iterations which comprised cycles of planning, action, observation and reflection. Each cycle was designed to build on the insights gleaned from previous cycles and incorporated newly refined elements of the normative framework.

In the first cycle, the standard three stage CPS model was explained to the team, who were asked to follow this simple process model rather than the normative framework. The purpose was to explore the impact of following this simple process model and explore the extent to which this training and adherence to the three stage process might affect participants' experience of creative problem solving. In the second cycle, the first stage in the normative framework, namely the interrogative information search was applied. In the third cycle, the approach to problem framing incorporated in the normative framework was employed. After each of these cycles, insights gleaned from focus groups, interviews and participants' completion of questionnaires, as well as insights gained from observation of the process were used to refine the normative framework.

PAPER 4

The fourth cycle deployed the refined framework which was used to solve a new problem to explore participants' experience of this enhanced version of the normative framework.

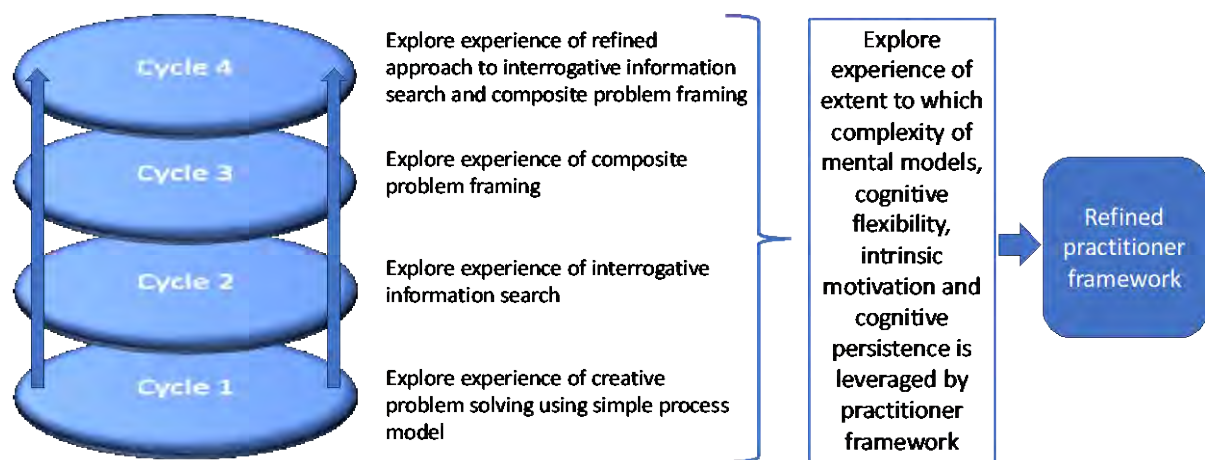
Participants were therefore successively exposed to each of the key elements of problem construction addressed in the normative framework in order to assess their perceptions and experience of these elements. This gradual exposure allowed them to home in on their experience of each element and report back on this experience in a relatively focused way.

Feedback on participants' experience was gleaned through direct observation, focus groups, personal interviews and the administration of a questionnaire. Relevant instruments employed are described in Section 30.4.1 below.

A graphical depiction of the design of this action research study is provided in Figure 22 below.

Figure 21

Research design for action research



An overview of these cycles is provided below and more detailed descriptions are provided in Section 31.

30.3.1 Objectives and approach for Cycle 1

As there is some evidence that simply following a structured process based on the stages of creative problem solving may enhance the creativity of small groups (Puccio et al., 2020) it was important to establish the impact of this factor alone, before employing the specific approaches to the information search and problem framing prescribed by the proposed normative framework.

The key objective of the first action research workshop was therefore to establish whether simply following the three high level stages in the CPS model would, in itself, facilitate more effective creative problem solving. In this workshop version 6.1 of the CPS framework (Isaksen, Dorval & Treffinger, 2000, 2004) was explained, after which the group was asked to follow the process. They were also instructed in the use of the DREAM TEAM ideation technique and asked to employ the DREAM TEAM as the ideation tool. The purpose of using the DREAM TEAM as the ideation tool throughout all four workshops was to allow for a common approach to ideation, such that this would not act as a confounding variable which could contribute towards any differences in the experience of participants between the different workshops.

The intention behind this approach was to ensure that any change in the experience of creative problem solving reported by the group would reflect the impact of applying the normative framework, rather than the potential impact of understanding and following the three stages of the CPS model. By design, therefore, the concentrated curiosity model and the approach to problem construction which reflects this in the normative framework, were not described or tested in this workshop.

30.3.2 Objectives and approach for Cycle 2

The primary objective of the second workshop was to evaluate the team's response to working through the interrogative information search framework. This workshop was also used to develop the conceptual map that would serve as the basis for problem framing.

After explaining the rationale for the interrogative information search, guidelines for working through the framework were discussed. While printouts of the interrogative information search framework were used to provide an overview of the framework, the team worked through the interactive version of the interrogative information search framework on the mind mapping software, XMind, such that their responses could be recorded and revised on the concept map during the workshop.

30.3.3 Objectives and approach for Cycle 3

The objective of the third workshop was to introduce the composite problem framing approach and assess the perceived value of this approach.

At the beginning of the workshop, a revision of previous stages was provided to ensure participants had a sense of context. Thereafter, the principles of composite problem framing and the logic behind it, namely a practical approach to conceptual combination, were explained. To enable more efficient use of the time available for the workshop, suggested composite problem frames had been prepared in advance, drawing on concepts flagged as high priority concepts by participants in the concept map of the problem produced by the interrogative information search.

Participants were then invited to use these suggested composite problem frames or to use an alternative combination of concepts. They elected to use the suggested problem frames with some minor modifications to wording. Participants were then asked to select two or three composite problem frames that they found most meaningful.

30.3.4 Objectives and approach for Cycle 4

For the fourth and last workshop, the group was asked to identify a new problem. The problem selected was one of the composite problem frames from Workshop 3. For the purposes of confidentiality, this problem has not been shared.

The objective of this workshop was to go through all steps in the revised normative framework, specifically the interrogative information search and subsequent composite problem framing, and then generate potential creative solutions to the selected problem frame. While, in the interests of providing a comprehensive normative framework, steps to be taken in the third stage of creative problem solving, namely, planning for action, are provided in the normative framework, it was explained that these steps would only be followed if time remained in the workshop.

As this thesis set out to develop a normative framework based on the theoretical model to optimise problem construction, feedback was not required on steps in the normative framework related to planning for action. The group was advised however, that they could opt for a separate workshop to evaluate and plan implementation of the set of ideas generated.

30.4 Data collection

A combination of participant observation, focus groups, semi-structured face to face interviews and questionnaires, was used to gather data for analysis. All interactions were recorded, with participants' consent, and these recordings were used to ensure reporting included relevant nuances in field notes and participant feedback.

Participant observation was conducted during all workshops and field notes were taken to record group processes and dynamics. Focus groups were facilitated with the team at the conclusion of each workshop. To facilitate comprehensive and consistent coverage of relevant issues, discussion guides were used (see Appendix F). While some questions were consistently posed, the discussion guide was tailored to enquire about the experience of implementing the specific elements that formed the focus of each workshop.

Semi-structured, one-on-one personal interviews were conducted with all participants in the team.

Interviews served two primary purposes, namely to allow participants the opportunity to share views they may not have wanted to share in the group setting and to ensure that individual differences in their experience of the creative problem solving approach adopted in the workshop could be fully explored and expressed. Questionnaires comprising open ended questions were used for this purpose (see Appendix F). As with the discussion guides, these varied across the four cycles.

Participants were also asked to complete questionnaires to ascertain whether they experienced any change in the four mediating variables of complexity of mental models, cognitive flexibility, intrinsic motivation and cognitive persistence, as a result of the process in which they had just participated.

30.4.1 Research instruments utilised in action research

Discussion guides used to facilitate the eliciting of relevant information from focus groups and questionnaires employed in the semi structured, one on one personal interviews are provided in Appendix F. As mentioned above, while the basic structure of the questionnaire and discussion guide was maintained across cycles, for each cycle certain questions were amended to ensure their relevance to the specific approach employed in that cycle.

To measure the mediating variables of complexity of mental models, cognitive flexibility, intrinsic motivation and cognitive persistence, the questionnaire developed, validated and used in the experimental study of Paper 2 was administered. A link to the questionnaire on Qualtrics was emailed to participants at the conclusion of the focus group to allow them to complete the questionnaires online after their interviews. As the first cycle did not require participants to follow the steps in the normative framework, questionnaires were not administered after the first cycle, which was also used to establish a baseline that would reflect participants experience of following the standard stages in the CPS process. The questionnaire was therefore administered after the second cycle during which the interrogative information search was introduced, and then again after the fourth cycle, in which both the interrogative information search and composite framing were used.

30.4.2 Reporting on responses to focus groups and questionnaires

With the consent of participants, all workshops, focus groups and interviews were recorded to enable subsequent documentation of the relevant comments and feedback. Responses to both focus groups and interviews have been documented in such a way as to capture points made while editing grammar and language where necessary without compromising content. Direct quotes are included in reporting on responses to interviews.

30.5 Data analysis and interpretation

The rationale for using four different sources of data in this study was so that each could contribute slightly different perspectives on the experience and effectiveness of working through the framework. The purpose of taking field notes was to record behaviours and conversations that would offer insights into participants' reactions which they might not want to express directly, or of which they might not be aware. By way of example, field notes would report on times when the conversation became unfocussed. The purpose of the focus groups was to encourage conversation about participants' experience such that a comment by one participant might be triggered by a comment by another. Conversations in the focus group were facilitated accordingly, with the aim of exploring and expanding on perspectives. The purpose of the interviews was to allow participants the opportunity to comment on group dynamics, as in a focus group setting, there would likely be reluctance to offer such perspectives. For example, in an interview, participants might be comfortable expressing that one individual typically dominates problem solving efforts. Questions in interviews also focussed on the individual's experience of their own challenges in creative problem solving, with the one-on-one context giving them the space to express themselves freely. The questionnaire was administered with the specific purpose of getting feedback on the mediators in the concentrated curiosity theory.

While responses to questionnaires yielded data that enabled limited quantitative analysis, the dominant mode of analysis of data from this study was qualitative. According to McNiff (2013), qualitative analysis of data from action research requires comparing data with the criteria that describe expected outcomes and the standards that define the degree to which outcomes are realised. Kemmis et al. (2013) similarly explains data analysis in action research as reflection on evidence "...to see what the evidence reveals about whether things went as you had planned." (Kemmis et al., 2013, p. 107).

Based on this prescribed approach, the desired outcome is that the normative framework should enable more effective creative problem solving. 'Standards' that determine the degree to which outcomes are realised, as defined by McNiff (2013), are informed by the concentrated curiosity model, such that these would be described as:

- increased curiosity about the problem,
- development of more complex mental models of the problem,
- increased intrinsic motivation to solve the problem,
- improved cognitive flexibility by asking new, previously unexplored questions about the problem,
- the ability to home in on specific relevant issues, and
- enhanced ability to apply cognitive persistence to solving the problem.

Each stage of this study therefore undertakes detailed comparative analysis in which feedback from the data sources is compared to these standards, or objectives. McNiff and Whitehead (2011) recommend the use of triangulation, such that multiple data sources are drawn on to inform reflection in action research. Accordingly, in this study, triangulation has been used in analysing the extent to which the application of the normative framework has achieved these standards, as the comparative analysis is informed by analysis of field notes, responses to focus groups, personal interviews and questionnaires, as described above.

Analysis of qualitative data emerging from action research also involves identifying emergent patterns (McNiff & Whitehead, 2011). Such emergent patterns and themes were related back to the expected outcomes, including ways in which the effectiveness of the framework could be enhanced and guidelines to be applied in its implementation. Therefore while the primary mode of analysis as described above was to compare the actual with the expected experience, in seeking out emergent patterns it was also necessary to scan evidence to identify effects that were not anticipated (Kemmis et al., 2013).

This report includes the feedback received from action research participants, interpretations of implications regarding the effectiveness of the normative framework in meeting its objectives, and resultant revisions to the framework.

30.6 Compliance with criteria for quality of qualitative analysis

As qualitative analysis requires compliance with a range of criteria, on which opinions vary, the set of eight criteria developed by Tracy (2010) has been selected as a checklist against which this analysis is assessed in Table 28 below. Yadav (2022) comments that while there is no universally common set of guidelines for assessing qualitative research, Tracy (2010) provides a set of criteria that is relevant to a variety of different qualitative research methodologies.

Table 28

Compliance with eight “Big-Tent” criteria for excellent qualitative research (Tracy, 2010)

Criteria for quality (end goal)	Mode of achieving the end goal	Compliance with criteria
Worthy topic	The research topic is: relevant; timely; significant; interesting	While organisations value creativity and regularly encounter complex problems which could benefit from creative solutions, currently no structured, evidence based methodology exists. Testing this normative framework in a real world setting enables this thesis to leverage theory to make a meaningful methodological contribution.
Rich rigor	The study uses a sufficient, abundant, appropriate, and complex: set of theoretical constructs; context(s); data and time in the field; data collection and analysis processes; sample(s)	This study provides a field test of the theory upon which this normative framework is built. While the sample of participants was limited, data was gathered through extended time spent with participants, in over 18 hours of workshops and focus groups, after which interviews were also conducted. In this time, work conducted and reflection allowed for in-depth observation and intensive interactions. Implementation of the normative framework at the company offices also enabled the research to be conducted in a real world context.
Sincerity	The study is characterized by: self-reflexivity about subjective values, biases, and inclinations of the researcher(s); transparency about the methods and challenges	Research participants were frequently reminded that criticism of the normative framework would be very valuable in enhancing it. Aspects of the workshops found to be challenging for participants and feedback that did not endorse the normative framework are provided.
Credibility	The research is marked by: thick description; triangulation; multivocality; member reflections	This study included multiple sources of feedback, including notes from observation, focus groups, interviews and questionnaires. Detailed descriptions of feedback and insights are provided.

Criteria for quality (end goal)	Mode of achieving the end goal	Compliance with criteria
Resonance	The research influences the audience through: aesthetic, evocative representation; naturalistic generalizations; transferable findings	Findings specific to this organisation, such as team dynamics, managerial priorities and challenges of employees can be generalised to other organisational contexts.
Significant contribution	The research provides a significant contribution: conceptually/theoretically; practically; morally; methodologically; heuristically	The study provides a theoretical contribution, as the theoretical model was tested in practice. It also provides a methodological contribution which addresses a gap in the research literature as well as in organisational practice.
Ethics	The research considers: procedural ethics (such as human subjects); situational and culturally specific ethics; relational ethics; exiting ethics (leaving the scene and sharing the research)	An important ethical consideration was confidentiality, which has been maintained in the reporting of findings. A confidentiality and non-disclosure agreement was signed with the organisation and content from the report that might be viewed as confidential has been reviewed by senior company representatives to ensure compliance with this commitment to confidentiality. Details of the problem and approaches to addressing it have therefore not been shared in this thesis. Participants signed consent forms which included details of the research. Insights gained were shared with the company.
Meaningful coherence	The study achieves what it intends to be about; uses methods and procedures that fit its stated goals; meaningfully interconnects literature, research questions/foci, findings, and interpretations with each other	Action research was an appropriate methodology for exploring the effectiveness of the normative framework as the goal was to explore nuances in organisations' receptiveness to the approaches and the extent to which it enhanced their ability to solve problems creatively. It also enabled an iterative approach of applying insights gained back into the normative framework. The report also drew on insights from the literature to supplement the interpretations of findings. Finally, conclusions are drawn from this study that provide input into theoretical propositions made in previous papers.

(Source: Tracy, 2010)

30.7 Limitations of this study

The transferability and dependability of the findings from this study are limited by the use of a single organization as a case site. However, this limitation is somewhat mitigated by the fact that the normative framework was tested in an organization of a different size and in a different industry to that used in the experimental study. Furthermore, by refining the normative framework in this specific organization for whom the generation of creative solutions was deemed so important, participants were highly engaged in the process, such that feedback provided was based on in-depth involvement with the process. To counter-balance the argument regarding the potential limitation of using a single organisation as a case site, a contrary argument is that in-depth research conducted in one case site is well suited to highlight gaps in the theory and immersive involvement with a particular case site and the resultant richly nuanced insights can lead to the development of new insights about the theory (Siggelkow, 2007).

A further limitation was that due to time constraints, the final stage in the CPS process, planning for action, was not implemented. Therefore feedback was limited to the perceived creativity of ideas generated in the ideation stage, rather than the creativity of selected and fully developed solutions.

Time and scheduling constraints also meant that certain suggested revisions to the normative framework, such as scheduling more, shorter workshops could not be implemented for this study. Other revisions that pertained to the final stage of planning for action also could not be implemented, as testing problem solvers' experience of these stages fell outside the scope of this study. Revisions that would support implementation of the interrogative information search without a facilitator were also not implemented, as the format of this study required the involvement of the researcher as facilitator.

While every attempt was made to ensure that no bias entered the interpretation of feedback received, the researcher facilitated the workshops and had a clear vested interest in the success of the methodology. To mitigate against the risk of this bias, the researcher clearly communicated to participants before beginning focus groups that any feedback would be used to improve the normative framework and if there were criticisms, these would be very useful to the researcher.

This study conforms to the criteria of credibility and confirmability in that participants were informed upfront as to how their feedback was to be utilised and participants' feedback on the normative framework was integrated into the framework such that the revised version was tested by the same participants in the final cycle.

31 CYCLES AND RESULTS OF ACTION RESEARCH STUDY

This section of the report is structured to provide the plan, data gleaned, and analysis of data from each of the four cycles. Firstly the description of the cycle contains an overview of the plan for that cycle which specifies the approach to planning, action, observation and reflection (Kemmis, McTaggart, & Nixon, 2013). Subsequently, field notes from observing participants in the workshop, analysis of these field notes, feedback from focus groups, analysis of focus group feedback, responses to interviews and analysis of these responses follow. For Cycles 2 and 4, responses to questionnaires and analysis of these results are also provided.

31.1 Description and results of Cycle 1

31.1.1 Planning, action, observation and reflection conducted in Cycle 1

Planning in Cycle 1: An introductory online meeting was held with the team to explain the objectives of the study, how it would proceed and the researcher's dual role as both a facilitator and observer of the process. In this meeting, the team was asked to identify a complex problem facing the business that they would like to address in the first three sessions. The problem they identified was to improve profitability. It was then explained that in the fourth and final cycle, the team would work on another problem of their choosing, such that they would have an opportunity to apply the refined normative framework in its entirety. As they would have spent three sessions working on the first problem, they would need to work on a fresh problem for this cycle. This would also assist in the assessment of whether the refined normative framework would be relevant to another problem.

A session was then scheduled to conduct creative problem solving on the first problem they had identified.

Action in Cycle 1: At this session, the traditional creative problem solving framework based on CPS version 6.1 (Isaksen, Dorval, Treffinger, 2000, 2004) was explained to the team. Particular attention was paid to the role of problem construction.

The team then followed the steps in problem construction, namely the information search and problem framing, after which they used the DREAM TEAM as an ideation tool. The researcher facilitated the process but maintained a relatively passive role so as to allow participants to experience only the impact of following the standard process steps depicted in this model .

Observation in Cycle 1: The creative problem solving process was observed, and data was gathered both by direct observation of the process and by soliciting feedback from participants in a focus group and personal interviews.

Specific issues investigated were:

- i. the perceived effectiveness of understanding and following the standard process steps,
- ii. the perceived utility and originality of the solutions generated
- v. Frustrations encountered
- vi. Constructive suggestions
- vii. Any additional feedback on the process

Reflection in Cycle 1: The data gleaned was analysed to assess the perceived effectiveness of the process and identify factors that support and detract from the effectiveness of the process.

31.1.2 Field notes from observation in Workshop 1

In addressing the problem of how to improve overall profitability of the organisation, the team initially seemed unsure of how to start looking for information about the problem. There was a strong tendency to identify questions but to avoid answering these. Questions raised were very broad. For example, the team asked:

- Where are we now?
- Where have we come from?
- Where do we want to be?
- Where is the problem?
- What are our constraints?
 - What do we know about them? What don't we know about them?
 - How do we find out what we don't know?

Thereafter, the team agreed that they had enough questions and should go through them one by one and answer them, but they then continued to pose additional very high level questions. The next questions they jotted down on the whiteboard were:

- Where are we?
- Where do we want to be?
- What is the gap?

Participants expressed frustration at their lack of progress as they felt they were going over ground that had already been covered and were not coming up with any new answers. At this stage, the researcher felt anxious at the team's frustration, but, as the intention was to explore the team's default approach without external intervention, she maintained her observer status.

The decision was then taken to address the question of "where are we" by mapping out a tree diagram comprising elements in the income statement. This elicited a higher level of focused engagement, as participants appeared to have a clearer sense of direction as to how to contribute relevant information.

The tendency to broaden the scope of the discussion to a more abstract level emerged again however, as one participant interjected : “It’s all about strategy”. At this point, it was observed that the conversation seemed to lose focus again and drifted into theoretical discussions that did not pertain specifically to their problem. It was observed that there was a strong tendency to cycle back to issues already highlighted. The group therefore seemed to find it difficult to explore new aspects of the problem.

Breaking the problem down by depicting elements of the income statement in a tree diagram did appear to provide the group with a greater sense of the issues to be addressed, such that when asked to then develop a problem frame, this was more focused. The original problem frame of “How can we increase profits?” was modified to “How can we better serve both Market A and Market B?”. These terms are used to protect confidentiality.

The team was then asked to use the DREAM TEAM ideation tool to generate potential creative solutions. Due to confidentiality, the proposed solutions cannot be divulged. Again, in keeping with the objective of this first workshop, this ideation process was not actively facilitated after this ideation tool had been explained to participants. Nevertheless, engagement in the process was relatively high.

31.1.3 Analysis of field notes from Cycle 1

From observation of the manner in which the team looked for information on the problem, it appeared that the team had difficulty answering the questions they posed, especially when they were very broad and theoretical. When the decision was taken to address the question “Where are we now?” by breaking it down into the specific question that required them to identify the key elements in the income statement, participants started to contribute answers. This suggests that the tendency to avoid answering questions is due to difficulty answering questions posed at a high level of abstraction. It was also interesting to note that the group represented the elements of the income statement in a tree diagram, which provided a structured approach to the visual representation of the information.

It was clear that in the initial discussion, participants were skirting around the issue as they weren’t sure how to approach it, but when the format of the income statement was employed, all team members displayed more confidence in their participation.

The DREAM TEAM technique was easily understood by all participants, who generated a number of ideas for each of the prompts without needing facilitation to urge them to continue generating ideas. It appeared again that having a structure encouraged them to explore different aspects of the problem. This inference was endorsed by feedback from interviews.

31.1.4 Focus group feedback after Workshop 1

Feedback on the questions posed to the group, as per the discussion guide, is provided below.

Participants agreed that they had a couple of things to investigate, but didn't have solutions. The ideation technique was considered useful in helping them to focus their thinking.

One sentiment expressed was that nothing new had come up in the discussion and the solutions generated weren't more original than solutions they have come up with before. This participant expressed that they were no closer to solving the problem. About 50% of the solutions were felt by some to be very useful and practical. But again the view was expressed that they had not found any real solutions or actions going forward.

A newer staff member claimed to have learned a few things and said that in the past, elements have been discussed in "bits and pieces" but discussing them all together was useful. One respondent said that it had helped to develop a deeper understanding in that different aspects of the problem were discussed together, and that certain concepts raised might be worth exploring further.

The DREAM TEAM tool was highlighted as having been useful in getting them to approach the problem in different ways. One comment was that the 'Emulate' prompt made them aware that they aren't sure of what competitors are doing and opened their eyes to the possibility of exploring this further. The DREAM TEAM was seen as effective in asking the right questions and supported a higher level of focus on the relevant issues in solving the problem.

While one respondent did say the process had made them more interested in the problem, they and others also felt it was a little demotivating as they felt daunted by the size and complexity of the problem. A view was expressed that the process itself did not facilitate greater commitment or focus, but the fact that for the first time this group sat together to work on this problem might have facilitated a greater level of commitment.

31.1.5 Analysis of feedback from focus group in Cycle 1

As set out in Section 30.3.1 and 31.1.1, the key purpose of the first workshop, which did not include any elements of problem construction developed in the normative framework, was to establish whether simply learning about and following specific process steps could have enhanced the effectiveness of creative problem solving.

Feedback clearly indicated that understanding and working through the process steps in three stages did not enhance the effectiveness of their creative problem solving. While the group agreed that the DREAM TEAM was valuable in helping them to generate potential solutions, they did not feel that the time they had spent trying to get information about and frame the problem had been useful in preparing them to generate more creative solutions.

This feedback indicates that the group found that simply taking the time to discuss the problem, look for information about the problem and consider potential alternative problem frames was not useful in and of itself.

31.1.6 Feedback from personal interviews after Workshop 1

Responses to the questionnaire used for personal interviews conducted after workshop 1 are proved below:

- 1. Have your attempts to come up with creative solutions in the past been conducted mainly as a team or on your own?**

Respondent 1: CIO

"Mainly worked as a team"

Respondent 2: Business Improvement Engineer

"Typically as a team"

Respondent 3: Branch accountant

"Mainly on my own. This was the first time I'd met to solve a problem with others from a variety of different disciplines."

Respondent 4: Business Improvement Manager

"I would say 50:50. There was more team work pre-Covid. In my experience, the person accountable for resolving a problem typically takes on most of the responsibility for coming up with a solution on their own and the team then needs to buy in to the solution afterwards."

Respondent 5: Group Financial Manager

"Mostly on my own."

2. When it was as a team, what worked well and what challenges did you encounter?

Respondent 1: CIO

“It has worked well when there has been structure. It goes pear-shaped when people go off at a tangent and don’t take the time to listen, so structure and facilitation have certainly helped. “

“When problems are very big and complex, often teams don’t get their teeth stuck into it because it’s so difficult to choose what to focus on. It’s also important to be able to establish the shared concern about the problem as well as the motivation and openness to testing one’s assumptions. Often people like to share their opinions but are reluctant to have their ideas challenged. We also typically don’t look for the relevant data to substantiate opinions. We then lack the impetus to focus on getting problems resolved – especially when there is a lack of consensus on these unsubstantiated decisions. Then we’re stuck. And when we don’t believe there is an answer, we’re also stuck. Opinions are often strongly held, but one of the key challenges is getting solutions acted upon.”

Respondent 2: Business Improvement Engineer

“People need a voice and to have their opinions heard. When solutions are driven by one individual it can lead to misalignment and people can sabotage implementation of the solution. When people approach problem solving from their own niche, it doesn’t work well. There has to be a learning process incorporated into the creative problem solving process, otherwise there will be less engagement in the experience as people will find it less stimulating.”

Respondent 3: Branch accountant

“In my experience, when I might come up with a solution, someone from a different discipline might say that it’s not practical. Company politics can be destructive in shooting down ideas of someone they don’t like. This is exacerbated when people feel sensitive about others treading on their turf. What has worked well when we’ve worked as a team to solve a problem, is that it ensures there are no surprises. Solutions derived collaboratively get more buy-in.”

Respondent 4: Business Improvement Manager

“When all key stakeholders are not included in trying to solve the problem, those who don’t attend won’t buy in to the solutions developed and will challenge the assumptions of those who came up with a solution. This initial buy-in is really important. Another challenge with working as a team is that often people get distracted and lack commitment.”

Respondent 5: Group Financial Manager

“When the meeting is managed tightly by the chair, it works better. Someone needs to take the driver’s seat and direct the conversation. Everyone needs to be engaged and giving the matter their focused attention. Team problem solving fails when there is no real direction and people talk but nothing happens. Another pitfall is when strong personalities shut others’ ideas down which leads to a decrease in engagement and participation.”

3. To what extent do you think the approach we used today might be helpful in improving your creative problem solving as a team?

Respondent 1: CIO

“I would use the DREAM TEAM. I found the facilitation valuable in that it provided additional prompts of issues to consider and I believe it kept the group on track by managing the process. If you could have facilitated more actively, this could have worked even better.”

Respondent 2: Business Improvement Engineer

“We always get together to solve specific problems but never to tackle the most important problems for the business. I think that using a specific process may serve as a catalyst to get us to focus on problems together on an ongoing basis. We also need to share experiences of and perspectives on a problem and today’s process took a step in that direction as it wasn’t about one person’s opinion predominating. The approach we took was to level the playing field and create an environment where we could be heard.”

Respondent 3: Branch accountant

“If you try to brainstorm, you tend to look at only one aspect of the picture. Using the DREAM TEAM helped us to consider a far greater variety of different aspects.”

Respondent 4: Business Improvement Manager

“As I was away and had to participate online in the session, it was difficult for me to engage fully.”

Respondent 5: Group Financial Manager

“The DREAM TEAM helped to focus our thinking. Brainstorming that is too broad doesn’t work. We need approaches to help to direct our thinking.”

4. What else do you think could be done to improve the effectiveness of your team dynamics in creative problem solving?

Respondent 1: CIO

"It would be more effective if people were made to stop and listen to others' input. People need to be more open to questioning and testing beliefs. Team members should focus more on exploring ideas rather than protecting their ideas and being defensive."

Respondent 2: Business Improvement Engineer

"We need to get the perspectives of different team members and be willing to challenge our own limitations."

Respondent 3: Branch accountant

"I would have liked broader representation – especially from teams who are responsible for implementation."

Respondent 4: Business Improvement Manager

"It would help if we could work on getting more input on the problem. Not everyone feels the impact of the problem so we need to define what the issues are at the outset so that everyone understands it."

Respondent 5: Group Financial Manager

"I don't have any suggestions at the moment."

5. When you worked on your own to come up with creative solutions, what worked well and what didn't work well?

Respondent 1: CIO

"I am very structured and methodical and follow a process, even if this isn't overt. I'll get to an action and execute against these but I find working with a team to be far more effective as different ideas and perspectives can feed off each other. This makes the process far more creative, stimulating and interesting. Team creative problem solving is also more effective as it's difficult to challenge your own ideas."

Respondent 2: Business Improvement Engineer

"I've used several different approaches. I might put the problem to the back of my mind and allow the solution to emerge on its own, or if I have a lot of experience in the issue then I might just need to validate my own opinions. The biggest challenge in problem solving on my own has been when I try to think about it too much, such that the solution can be elusive. This may happen when I have a blind spot that's preventing me from seeing something. I need others to challenge my blind spots."

Respondent 3: Branch accountant

"If you have no one challenging you or asking questions or reminding you of what has been tried before, you can get over enthusiastic about a solution you come up with."

Another challenge is that as an individual, you typically don't set aside the time to work on the problem. There are advantages to working on your own though. It is nice to have the space to consider all the issues on your own without anyone challenging or second guessing you. Others can make you doubt yourself."

Respondent 4: Business Improvement Manager

"When solving problems on my own there is less push-back, but on the other hand, push-back is necessary. When an individual has a biased approach to issues, it makes individual problem solving less effective than team problem solving, as one doesn't get one's views challenged."

Respondent 5: Group Financial Manager

"It has worked well when I can close the door and think deeply about the problem. Being able to spend dedicated time is very important. I like to first get an understanding of what the problem is and then work through it systematically. I ask what data I need and work through what needs to be done. It doesn't work as well when I follow an unstructured process, and when the problem being tackled isn't the actual problem."

6. To what extent do you think the approach we used today might be helpful in improving your creative problem solving when working on your own?

Respondent 1: CIO

"I would certainly use the DREAM TEAM when working on my own."

Respondent 2: Business Improvement Engineer

"It helped me to understand the roles and accountabilities of different role players in the problem but we all had the freedom to contribute without deferring to our particular roles."

Respondent 3: Branch accountant

"DREAM TEAM opened up a variety of different avenues to explore. This makes you realise that there are many more ways to approach the problem which can help you to generate far more potential solutions. It helped me to think of ideas that I wouldn't have considered previously."

Respondent 4: Business Improvement Manager

"It's important to define the problem and then make sure one has key take aways regarding this at the end. The three stage structure helps to emphasise the value of stages one and three, so that there is enough focus on problem construction and the fact that you need clear take aways which you can implement. We usually tend to jump into finding solutions."

Respondent 5: Group Financial Manager

"I would use the DREAM TEAM."

7. What else do you think could be done to help you to be more effective in creative problem solving when working on your own?

Respondent 1: CIO

"Anything that could help me to look at things from multiple perspectives and force myself to see the problem through the eyes of another person and from another domain would be useful.

I would also like to have more access to information from various people. Input from others about the feasibility of implementing a potential solution would also be very useful. We are very collaborative and it's very rare that I would solve a problem on my own. In fact that might be our Achilles heel as it's often difficult to get people together to solve a problem."

Respondent 2: Business Improvement Engineer

"It would be helpful to introduce more structure right at the beginning of the problem solving process. I also need to learn to not take things too seriously."

Respondent 3: Branch accountant

"It would be very valuable to take the time to sit back and reflect on certain problems. We are usually too rushed to dedicate the necessary time."

Respondent 4: Business Improvement Manager

"When working on my own again I think the emphasis on the three stages are useful to ensure enough attention is paid to stages one and three (problem construction and planning for implementation)."

Respondent 5: Group Financial Manager

"I can't think of anything else, other than following a structured process."

31.1.7 Analysis of feedback from interviews in Cycle 1

A Problem solving as teams and individuals

People in finance tended to conduct problem solving more on their own, but expressed interest in more teamwork. Participants shared that the level of involvement of team members was not always optimal in creative problem solving, especially as not all stakeholders in the problem were brought in at the same time or afforded equal opportunities to be heard. While responses indicated that it may not be practical to have different stakeholders participate from the start, this concern may be addressed by the normative framework if the interrogative information search process is leveraged to elicit input from all stakeholders.

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In this way, even if all stakeholders cannot be present in an initial workshop, their input will still be sought at this early stage in the problem solving process. (See amendment in Section 31.1.8 below.)

The need to have everyone fully understand the problem and to explore aspects of the problem was also mentioned, as was the experience of different people having a 'biased' or misaligned perspective on the problem when they work on solving problems on their own. It is suggested that in individual problem solving the canvassing of opinions of different stakeholders to complete the conceptual map will support a more aligned and comprehensive understanding of the problem.

The challenge of having people resist accountability when creative problem solving may also be managed to some extent by allocating responsibility to specific individuals for completing certain elements within the interrogative information search framework. (See amendment in Section 31.1.8 below.)

B Resistance to having opinions challenged

The concern that when trying to solve problems people resist having their opinions challenged, was mentioned by a number of group members. This symptom of 'cognitive entrenchment (Dane, 2010) is one of the greatest impediments to creative problem solving according to Mumford et al. (2020). Problem solvers therefore need to be open to new ideas about their understanding of the problem.

One of the objectives of the interrogative information search is to encourage such openness by clearly establishing that the objective of the process is information gathering. This should ideally increase their receptiveness to new ideas. Based on this feedback from interviews, it was decided to test whether action research participants felt that engaging in the interrogative information search had supported their and their colleague's receptiveness to new ideas. This was done by incorporating a question to this effect in the interview discussion guide to be utilised after the final action research cycle.

C Preference for team work

The preference expressed for team work is notable, as it contrasts with the research results indicating the relative superiority in effectiveness of creative problem solving when individuals work on their own. Of course, enjoyment of an activity is not necessarily a precursor to optimal creative performance (Kurtzberg, 2005). However, it has also been found that positive affect contributes to creative performance (Seligman & Csikszentmihalyi, 2000). This implies that ideally, an optimal creative solving methodology should also be enjoyable.

It is suggested therefore, that attributes of individual problem solving that contribute to its relative effectiveness should be harnessed in the normative framework to optimise its effectiveness. (See amendment in Section 31.1.8 below.)

D The need for access to a diverse range of information

This is related to the point above about team work, but the need to obtain multiple perspectives in assessing the feasibility of implementing solutions is a point that should be incorporated as a process step in the last stage of the normative framework. (See amendment in Section 31.1.8 below.)

31.1.8 Revisions to normative framework post Cycle 1

A Additions to Step 2 of the normative framework: Guidelines for using the normative framework

1. All relevant stakeholders should be canvassed to provide input to answering questions and completing the resultant concept map of the problem. Such stakeholders may or may not be part of the creative problem solving team. Individuals conducting creative problem solving on their own should also consult broadly to elicit input on responding to questions in the interrogative information search framework
2. When completing the interrogative information search as a team, individual accountability may be allocated to team members for searching for relevant responses and additional questions regarding different aspects of the interrogative information search framework.

B Additional Step in normative framework: Harnessing the ability of individuals to integrate and create new knowledge

One key source of an individual's relative effectiveness in creative problem solving is the ability to combine and integrate information from a variety of different domains, such that they subsequently create new knowledge (Boh et al., 2014; Taylor & Greve, 2006). To harness this strength of individuals working on their own, a step was added to the normative framework. After Step 3, which involves the identification of new questions, individual team members are to review the resultant conceptual map to define new concepts by integrating existing concepts.

New Step 4.1: Individuals to identify new concepts based on conceptual integration

Individuals, acting independently, are to review concepts in each of the five categories in the conceptual map and ask themselves the following question:

"Which concepts in this category can be combined such that a new emergent concept can be identified?"

When creative problem solving is being conducted as a team, individuals should then report back to the team on the newly identified concepts and these should be incorporated into the conceptual map.

C *Addition to Planning for Action: Building on ideas with potential and project planning*

A broad range of stakeholders should be consulted to provide input into building on ideas with potential and considerations for project planning and implementation. This may include individuals external to the organisation.

31.2 Description and results of Cycle 2

31.2.1 Planning, action, observation and reflection conducted in Cycle 2

Planning in Cycle 2: A revision to the framework that was put into practice in this cycle, was inviting other stakeholders to provide input to the interrogative information search. A workshop was scheduled to conduct creative problem solving on the same business problem, using the interrogative information search framework. Although the original plan was to run one workshop to work through the interrogative information search framework, and subsequently ask individuals to review the concept map and give their input, the team agreed that they would rather schedule an additional workshop to continue working through this to develop the conceptual map. The revision relating to the third stage in the CPS process, planning for action, could not be implemented in this cycle as implementation of this third stage fell outside the scope of this study.

Action in Cycle 2: The second workshop involved more active facilitation. Team members were requested to work through the interrogative information search framework and develop a conceptual map. This was facilitated by recording responses to the questions in the interrogative information search framework in the mind map format.

Observation in Cycle 2: Data on the experience of using the interrogative information search framework was gathered both by direct observation and by requesting feedback from participants on their perceptions of the experience. Participants were also asked to complete the questionnaire on mediating variables after the focus group and interviews. Feedback was requested with regard to:

- i. the perceived effectiveness of using the interrogative information search framework,
- ii. the perceived utility and originality of the solutions generated,
- iii. the perceived levels of domain expertise, cognitive flexibility, intrinsic motivation and cognitive persistence elicited and brought to bear in the process.

- v. frustrations encountered
- vi. constructive suggestions
- vii. any additional feedback on the process

Reflection in Cycle 2: Data was analysed to gain insights into team members' experience of using the interrogative information search framework.

31.2.2 Field notes from observation in Workshop 2

At the start of the session, the methodology of the normative framework was explained. Feedback on concerns and satisfaction with the previous creative problem solving session was referenced when highlighting key points of difference from the approach they used before, with the aim of alerting participants to the practical implications of using the interrogative information search framework in the information search. Facilitation of this session was more active than in workshop 1. This was necessary both to guide participants through the questions as well as to assist the team in succinctly expressing the responses such that they could be recorded as concepts. Facilitation was also required to ensure that responses were specific rather than vague, theoretical or generalised. In attempting to answer a question, conversations around the topic often pertained to a specific example and the concept needed to be extracted. The researcher as facilitator also highlighted which concepts needed to be flagged as high priority issues, based on input from participants.

The process was very time consuming. The workshop to go through the interrogative information search framework was scheduled for three hours and it was found that another session of three hours needed to be scheduled to respond to the remaining questions in and complete the conceptual map. As this was a continuation of Workshop 2 and the aim was to complete the conceptual map of the problem, outcomes of this workshop have not been documented separately.

The process was found to be cognitively demanding, and at one point one of the participants laughed as they commented: "You expect a lot of brain power from us!"

At one point, when questions in the interrogative information search framework revealed gaps in participants' understanding of certain aspects of the problem, they invited two colleagues from another department to give their input. Participants came to realise, in the course of discussions, that more research was required to understand market trends as well as to analyse data, as a number of answers could not be provided and it was understood that research was required to do so.

31.2.3 Analysis of field notes from Cycle 2

The original intention was to start working through the interrogative information search in the three hour workshop and then for participants to work together as a team without facilitation to complete the concept map prior to Cycle 3. However, given the high degree of facilitation necessary, it was decided that individuals could not complete the conceptual map on their own, and the team decided they would rather schedule an additional three hour workshop with the researcher/facilitator to respond to the remaining questions.

As the workshops were long and required a high level of cognitive persistence, energy levels of some participants appeared to flag at some points.

In light of the cognitive demands placed on the participants, it was very interesting that responses to the process expressed in the focus group and interviews were so positive (See Sections 31.2.5 and 31.2.7 below). Furthermore, the fact that the team elected to schedule another three hour workshop to continue working through the interrogative information search framework was an endorsement of the value they perceived in the process.

Therefore, while team members may have found the exercise mentally taxing, their feedback indicated that they were motivated to persist in their goal of fleshing out their understanding of the problem. As the researcher was concerned that she was pushing the group too hard, and that this would undermine their motivation to devote the necessary energy to generating solutions, she was both surprised and relieved to learn that participants wanted to work through their cognitive fatigue. This is interesting in light of the findings of Baas, De Dreu and Nijstad (2011) that unrealised attempts in attaining certain goals or end states drives cognitive activation, which in turn drives creative performance.

Inviting two colleagues from another department to share their perspectives indicated that working through the interrogative information search framework highlighted to participants that there may be gaps in their understanding of different aspects of the problem. Perspectives shared by these colleagues did in fact reveal attitudes that might well be contributing towards the problem.

The realisation of the requirement for additional research illustrated that awareness of the need for an expanded and deeper perspective on the problem was required. Such awareness indicated that the element of doubt had been triggered, as working through the interrogative information search framework had highlighted gaps in their knowledge. This sparking of doubt was one of the objectives of the concentrated curiosity model.

31.2.4 Focus group feedback after Workshop 2

Participants reported that they had found the process very useful. They found it very useful to follow a framework. One participant said: "It has you asking the right questions, it has you focused and it has you thinking about things differently." Another participant said that it helped them to get clarity on the problem. One participant agreed that their understanding had been deepened as, for example, she had never before sat down and asked questions to clarify what their clients really want from them.

The team agreed that their perspective had been broadened, with one participant saying that they had never before understood how many elements there were to the problem, and that the different questions helped them to come at the problem from different angles and appreciate the different issues.

There was agreement that it had made them more curious about the problem. As one participant described it, it made her question assumptions that she had previously not thought to challenge. She said that she now felt curious and was motivated to get her hands on relevant research to explore the bases of her assumptions. Another participant said that he was now curious about evaluating different options.

The team agreed that there was a logical flow which made it easy to follow.

They expressed a need to spend more time going through the interrogative information search framework before moving into solutions. They felt this would be beneficial in enhancing the creativity of solutions.

As the team felt that they hadn't had enough time to work on generating solutions, they felt that these were not more original. They felt that solutions generated in the short time available in the workshop had definitely been more useful and practical as going through the interrogative information search framework had given them a far better idea of what the problem was, enabling a deeper dive.

There was consensus that they were now considering different approaches to the problem and seeing it in different ways.

The group said they were definitely now more interested in the problem and more motivated to solve it, though they now understood the magnitude and complexity of the problem more than they had before, which also made it more daunting. They agreed that they had definitely applied their minds in a more focused and disciplined way. Again, they felt that they needed more time as they liked the process and much preferred it to the kind of approach whereby everyone is just asked for their thoughts. This process, they agreed, helped them to think outside the box.

They also appreciated being able to unpack the process as a team, such that they would all have a similar understanding of the elements of the process. They felt that the reason the problem had persisted for so long was that given that it was so big and complex, no-one was prepared to tackle it. Using this process, the problem became less overwhelming as it was broken down into smaller pieces. It also helped them to reveal and challenge assumptions about the problem.

There was an additional endorsement of the value of working on the problem as a group, and the team expressed interest in getting more of their colleagues to contribute to the process.

They felt that the most effective way of eliciting useful input from their colleagues in other departments would be to invite representatives from other departments into a session in which they would be asked to contribute their responses to certain questions. When asked whether they would want to work through the interrogative information search framework on their own as well, they responded that the prospect of working through the process in a group for three days was very stimulating but they would not want to work through it on their own.

They also mentioned that the approach they had used in this workshop gave them a sense of the problem solving process having a beginning and an end, and they could see where they were in the process. They felt as if they now had a roadmap to follow in solving the problem.

31.2.5 Analysis of feedback from focus group in Cycle 2

The interrogative information search framework was well received by the team who found it particularly useful in breaking down such a broad, complex, unbounded problem in a way that clarified the moving parts within the problem and their relationships between each other.

Given their strong preference for problem solving as a team, they also found that working through the framework together helped them to channel their input into the development of a shared perspective of the problem and they expressed interest in using the framework to access inputs from different departments by asking them to respond to specific questions.

The facilitation of more effective teamwork was not originally one of the goals in the development of the interrogative information search framework, but feedback from the team clearly indicated that this was a side effect of working through this framework. Another unexpected outcome was that this process is actually more effective when used by a team, as individuals felt that they would prefer to work on it as a team rather than on their own.

By helping them to explore different aspects of the problem, participants also felt the approach had sparked their interest in solving it, as the process revealed new angles to investigate.

It appeared that the structure was found to be especially valuable, as was suggested by comments to the effect that they now felt the problem had a beginning and an end and they could see where they were in solving it. While feedback was that the process did not simplify the problem, but rather revealed its complexity, it did so in a way that made it easier to tackle.

The researcher originally assumed that a three hour workshop would be sufficient to work through the problem, and that participants would resist having to spend additional concentrated time working through the framework. This assumption was dispelled by feedback from the focus group, which clearly expressed participants' desire to spend additional time on this stage in the process. In fact, one participant commented that they had moved too quickly to coming up with solutions and would be willing to work through this process for three days before ideating. This interest in, and commitment to spending more time working through the normative framework may be taken as an endorsement of the perceived value of the process.

31.2.6 Feedback from Personal Interviews after Workshop 2

Responses to the questionnaire used for personal interviews conducted after workshop 1 are proved below:

- 1. To what extent do you think the approach we used today might be helpful in improving your creative problem solving as a team?**
 - a. Any suggestions as to how the process could be improved to better support effective teamwork?**

Respondent 1: CIO

"I think it was helpful to a large extent. I wouldn't suggest any changes as everyone was engaged."

Respondent 2: Business Improvement Engineer

"It allows people with skills and knowledge in different areas to contribute in different ways. When there is no structure, the agenda is often biased, so there is a lack of buy-in. The approach we used today allows for more buy-in. It also helped to clarify issues for everyone. We could benefit from running a series of sessions, allowing for cross pollination of ideas by involving different people from different areas of the organisation. This would provide more perspectives on the problem and offer a reality check. In this way we can also solve problems more holistically."

Respondent 3: Branch accountant

“The approach we used today helped us to break the problem down in a lot more detail. I found it especially useful to look at what different clients need, as I have learned how to look at this from different perspectives. This process has made me a lot more curious about these different client needs and I would like to learn a lot more about this. We could use a lot more time on this. In fact we could use a five day workshop going through this process.”

Respondent 4: Business Improvement Manager

“It was very good. I think the process is useful to use as a team as it opens up dialogue and prevents strong individuals from dominating the conversation. The visual representation in the mind map was very useful.”

Respondent 5: Group Financial Manager

“It helped us to focus our thinking and gave direction on how to break things down before jumping into developing solutions. New questions also then pop up more in the team.”

- 2. To what extent do you think the approach we used today might be helpful in improving your creative problem solving when working on your own?**
 - a. Any suggestions as to how the process could be improved to better support your individual creative problem solving?**

Respondent 1: CIO

“I would use it more as a team, but then I would find it useful to reflect on the conceptual map on my own subsequently. If I were to complete the interrogative information search on my own, I wouldn’t follow the process with the same level of rigour as when doing it with a team. Perhaps there could be a shorter version to use when doing this on one’s own.”

Respondent 2: Business Improvement Engineer

“I would need more practice in the approach before answering this, but I think a real strength of this process is its effectiveness when used in a team.

The way this has been designed is really great. It carries more weight at a strategic level than at a functional or process level, as at the strategic level there is more ambiguity and complexity.”

Respondent 3: Branch accountant

“It made me want to know more. I want to know what it costs to service different clients. I’m very curious to look at the numbers and see what they tell us. The process awakens curiosity about the problem.

If I was working through this on my own I would like to get input from other people to answer questions, so I would engage with other departments.”

Respondent 4: Business Improvement Manager

“I would use this on my own. Perhaps it would be useful to have this as an app when working on one’s own.”

Respondent 5: Group Financial Manager

“I would use it as a guideline to raise discussion points but I wouldn’t apply the same level of rigour when working through this on my own.”

3. To what extent has answering these questions helped you to see your problem differently?

Respondent 1: CIO

“Looking at the finer details has helped me to see it differently. Stopping and thinking about it from different perspectives is very helpful.”

Respondent 2: Business Improvement Engineer

“I see the problem differently as I see it more clearly, and that motivates me to solve it.”

Respondent 3: Branch accountant

“It has helped as I did think solutions were just limited to one approach. Now different options are opened up. It has really made me think of the problem differently. Before I thought there could be a simple solution, but this opened up more options and made me interrogate my thoughts.”

Respondent 4: Business Improvement Manager

“I’ve normally had to picture the different variables together. It was very useful to see the variables visually represented together.”

Respondent 5: Group Financial Manager

“It was very helpful. Things you wouldn’t have thought possible to think of come up in your thinking. I found my thinking shifting constantly so that I kept thinking of different things.”

4. Which (if any) questions or aspects of the framework helped you to think of your problem differently or find a new angle or perspective on your problem?

Respondent 1: CIO

"The breadth of questions is very helpful in making sure that you are comprehensive in breaking it down and not leaving it too quickly. It helps to ensure that you cover all the bases and work through them thoroughly."

Respondent 2: Business Improvement Engineer

"It's useful to frame the desired outcomes clearly and then follow through to dependent sets of questions. It's also useful to look at factors in and outside RAM."

Respondent 3: Branch accountant

"It helps to break down the obstacles in processes and to see how different obstacles related to different customer groups."

Respondent 4: Business Improvement Manager

"The process in general was useful. It was comprehensive and very well thought out."

Respondent 5: Group Financial Manager

"I can't pick one."

5. Did any new questions emerge for you as a result of your information search?

Respondent 1: CIO

"Not that I can think of."

Respondent 2: Business Improvement Engineer

"Yes – I am able to articulate questions that I had before more clearly now."

Respondent 3: Branch accountant

"One big question that emerged is "What's in the market?" No-one knows. We haven't done this research. We need to do this research to work out what we can go after."

Respondent 4: Business Improvement Manager

"I did wonder if there were things we didn't consider but nothing comes to mind. I can't think of any gaps in the framework."

Respondent 5: Group Financial Manager

"Yes, new questions came up from me and from others."

31.2.7 Analysis of feedback from interviews in Cycle 2

A Integration of different inputs and perspectives

Participants valued the way in which people were engaged and the manner in which they were given a voice, by requesting input on different issues. When different issues are explored in detail, it provides people with many opportunities to contribute based on their experience in this range of issues.

The value of using the interrogative information search process in a team was again reiterated, with two participants asserting that if they were to follow the process on their own, they wouldn't use the same level of rigour as they would in a team.

B Scheduling the necessary time

While participants agreed that they would like to spend more time on this process, there were some who said that concentrating for so long in a single session was a challenge for them and that they would prefer the process to be divided into shorter sessions.

C Increase in curiosity and cognitive flexibility

The role of the interrogative information search framework in encouraging curiosity about the problem was well endorsed by some participants, who spontaneously mentioned how the process made them feel more curious. The increase in cognitive flexibility was also alluded to, as in the comments: "I found my thinking shifting constantly so that I kept thinking of different things", and "...this opened up my thinking and made me interrogate my thoughts."

D Structure and visual format

The suggestion was made that if an app of the framework could be developed, this might make it easier to follow the process on one's own.

The visual representation in the mind map format did seem to help participants appreciate how the different variables of the problem are related to each other. This was consistent with research illustrating that especially when dealing with complex problems, mind mapping facilitated the assimilation of dense information and relationships in a way that supported fluency and originality of creative problem solving (Malycha & Maier, 2017).

The process flow was also found to be useful in ensuring that there was comprehensive consideration of a broad scope of issues.

31.2.8 Responses to questionnaire on mediating variables after Workshop 2

Responses to questionnaires submitted to participants reflected the following self-reported changes in the four variables proposed as mediating variables in the concentrated curiosity model, between the first and second workshop in which the interrogative information search framework was introduced.

Table 29

Scores reflecting self-reported increase in mediators

Mediator	Mean	Std deviation	N
Complexity	5.6	0.88	5
Flexibility	5.5	1.02	5
Motivation	5.5	1.16	5
Persistence	5.4	0.73	5

The following Likert scale was used:

- 1 = Much less than on the last attempt
- 2 = Less than on the last attempt
- 3 = A little less than on the last attempt
- 4 = The same as on the last attempt
- 5 = A little more than on the last attempt
- 6 = More than on the last attempt
- 7 = Much more than on the last attempt

Therefore scores indicated that on average, participants felt the complexity of their mental models, cognitive flexibility, intrinsic motivation and cognitive persistence were higher than in the last workshop. On average, participants felt these states had increased to a modest extent, but would venture that they had increased by more than 'a little more'. Responses to the statements that comprise each of these scales are provided in Table 30 below.

Table 30*Complexity of mental models*

Statement in questionnaire	Mean	Minimum	Maximum	Std deviation	N
1. I knew what the different aspects of this problem were	5.5	4.8	6.6	0.70	5
2. I understood the obstacles to resolving this challenge	5.5	4.8	6.6	0.72	5
3. I appreciated the complexity of this challenge	6.2	6.0	7.0	0.39	5
4. I understood the most critical issues that need to be addressed	5.7	4.0	7.0	0.98	5
5. I understood the finer details of this issue	5.1	4.0	6.3	0.97	5

Of all items in this scale, the one that had increased the most was the appreciation of the complexity of the challenge. This was also the item with the lowest standard deviation, indicating that participants experienced similarly positive increases in this understanding of complexity.

Table 31*Cognitive flexibility*

Statement in questionnaire	Mean	Minimum	Maximum	Std deviation	N
6. I looked at this issue from many angles	6.0	5.0	7.0	0.90	5
7. I considered many potential solutions	4.8	4.0	5.6	0.55	5
8. I thought about this issue from other peoples' points of view	5.2	4.0	6.2	0.81	5
9. In evaluating potential solutions, I played out different scenarios in my head	5.6	4.0	7.0	1.06	5
10. I considered how potential solutions may or may not work under different circumstances	5.1	4.0	6.8	1.09	5

Given that available time to ideate was limited, it is not a surprising result that the lowest scoring item pertained to the consideration of many potential solutions. The item that scored highest on average indicated that after the interrogative information search, the problem was explored from more perspectives.

Table 32*Intrinsic motivation*

Statement in questionnaire	Mean	Minimum	Maximum	Std deviation	N
11. I enjoyed the process of solving this problem	5.7	4.0	7.0	1.08	5
12. I thought of this as a really interesting problem to try and solve	5.8	4.0	7.0	1.12	5
13. I thought of this as a challenge worth solving	5.0	4.0	6.1	0.92	5
14. I found myself absorbed in the process of trying to solve this problem	5.4	4.0	6.8	0.97	5
15. I thought I would be interested in spending more time trying to solve this problem	5.4	4.0	7.0	1.35	5

Interest in the problem increased after the interrogative information search. As the problem was to increase profitability of the business, which is clearly a fundamental issue, it is to be expected that participants were already of the opinion that this challenge was worth solving, such that this perception was only strengthened to a limited extent.

Table 33*Cognitive persistence*

Statement in questionnaire	Mean	Minimum	Maximum	Std deviation	N
16. I kept trying to come up with new ideas even when I found it difficult	5.6	4.7	6.1	0.60	5
17. Even after I had come up with some good ideas, I kept digging deeper to come up with better ones	5.3	4.5	6.1	0.36	5
18. I blocked out any distracting thoughts to ensure I was fully focused on the relevant issues	5.3	4.0	6.2	0.78	5
19. When an idea occurred to me, I thoroughly explored all the ways in which it could play out	5.4	4.0	6.0	0.75	5
20. I made sure that I examined all relevant aspects of the problem thoroughly	5.4	4.0	6.0	0.78	5

While participants reported modest increases in cognitive persistence, the relatively low standard deviation of 0.36 suggests that there was relative consistency in their experience of the highest scoring item, indicating that they kept pushing themselves to come up with new ideas more than they had before using the interrogative information search.

31.2.9 Analysis of responses to questionnaire post Cycle 2

While mean scores per item and per scale were modest, the fact that scores were based on feedback from only five participants suggests that nuances could be lost by basing interpretations on mean scores. Inspection of maximum and minimum scores could therefore yield insights. Using this approach it may be useful to note that maximum scores of 7, indicating states experienced as 'much more than before', were reported for two to three items for all mediators other than cognitive persistence. It was also interesting that the variable that increased the most was the complexity of mental models, which mirrored the results obtained in the experimental study.

31.2.10 Revisions to normative framework post Cycle 2

A Additions to the interrogative information search framework: Additions of explanatory notes

Participants needed some of the questions to be explained and clarified. If the framework is to be used without a facilitator, it would be useful to add explanatory notes to some of the questions. These could be added as pop-up notes that could be accessed by clicking on the relevant questions.

B Revision to workshop scheduling

Rather than scheduling one workshop to go through the interrogative information search framework, this should be divided into at least three sessions of two to three hours each.

C Development of an app

The feasibility of developing an app of the interrogative information search framework with prompts to facilitate progress through the questions, should be investigated.

31.3 Description and results of Cycle 3

31.3.1 *Planning, action, observation and reflection conducted in Cycle 3*

Planning in Cycle 3: Revisions to the normative framework that were based on input from Cycle 2 could not be incorporated into the workshop for Cycle 3, as two of the revisions were designed to support problem solvers working on their own, without facilitation, and one pertained to workshop scheduling, which could not be revised for this study due to scheduling constraints.

The workshop for Cycle 3 was planned to instruct and guide the team through the process of constructing a series of narrow composite problem frames.

Action in Cycle 3: A workshop was facilitated in which team members were requested to conduct creative problem solving on the same business problem drawing on the conceptual map developed by conducting the interrogative information search and developing a series of narrow problem frames using composite framing.

Observation in Cycle 3: Data was collected on the experience of the impact of the approach to problem framing as well as the normative framework as a whole. Such data was gathered both by direct observation and by requesting feedback from participants on their perceptions of the experience. Team members were asked to provide feedback on:

- i. the perceived effectiveness of the composite framing approach,
- ii. the perceived utility and originality of the solutions generated,
- iii. the perceived levels of domain expertise, cognitive flexibility, intrinsic motivation and cognitive persistence elicited and brought to bear in the process.
- v. frustrations encountered
- vi. constructive suggestions
- vii. any additional feedback on the process

Reflection in Cycle 3: Data was analysed to gain insights into team members' experience of the way in which the conceptual map could be used as the basis for developing a series of narrow composite problem frames.

31.3.2 *Field notes from observation in Workshop 3*

Only three of the original five participants were able to attend this workshop. This was only discovered at the beginning of the workshop, which then proceeded with the three participants.

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Discussion of the composite problem frames served to reveal that previous approaches to problem framing were based on assumptions which were often not supported by data. For example, data on customer needs and priorities was not available, such that approaches to develop solutions in the past had been based on assumptions about customer needs.

Participants also commented, while discussing these problem frames: “You are stimulating our creative thinking!”, and laughingly protested that these discussions themselves were provoking ideation, such that they were frustrated that they could not start, at that point, to come up with ideas but had to wait until they had selected the two to three problem frames on which they were to work before commencing with ideation.

The group found it difficult to prioritise and select the problem frames and engaged in lengthy discussions about which would be most important to address. Each participant proposed their top three choices and the group then discussed which they should use as the basis for ideation. It appeared that they were looking for a way to limit their options, as selecting three problem frames from nine was daunting when they all seemed important. In fact, in the focus group, it was mentioned that they would like a process that would guide them through the steps required to help them prioritise problem frames. This has been addressed in Section 31.3.8 in which revisions to the normative framework are proposed.

A pattern of discussion that emerged consistently, even when discussing problem frames, was the tendency for participants to constantly reiterate elements of a problem and how they relate to each other, emphasising the cyclical, and therefore intractable nature of the problem.

31.3.3 Analysis of field notes from Cycle 3

Participants’ responses to the composite problem framing provided support for the approach, both based on their feedback that they were “great problems” and by stating that these problem frames in themselves were stimulating their creative thinking. The approach of combining priority concepts from different categories was not seen as overly complex or difficult to follow.

It was noted that discussions that focussed on the cyclical nature of elements within the problem, and participants’ resultant frustrations gave rise to two phenomena: firstly, these discussions distract participants from looking for potential solutions, and secondly, they seem to convince participants that the problem cannot be resolved. When their focus was on the tight links in the causal chain, problem solvers appeared unable to home in on opportunities for breaking these links.

The need for focus emerged clearly from discussions. This was both expressly stated by participants and determined from the apparent frustration at tackling the interdependent elements of the problem and encountering the cyclical nature of these dependencies. This observation gave rise to a revision to the normative framework, namely an approach to specifically frame a problem such that it acknowledges and looks for ways to disrupt the systemic nature of complex problems. (See Section 31.3.8)

The need for focus was also reflected in the appreciation of the narrow scope of the composite problem frames, as opposed to the original broad problem frame, and in the need to home in on only one of the composite problem frames.

31.3.4 Focus group feedback after Workshop 3

The group agreed that this approach had helped them to frame the problems more effectively. They found that focusing on specific aspects helped them understand the problem better such that it could yield better solutions. There was also agreement that it helped them to see the problem in new ways and consider new aspects they had not considered before. Breaking the problem into narrowly focused problems was also considered effective.

There was a sense that this approach yielded more practical solutions as it made it easier to home in on key issues. They agreed that to get to this point they needed to see all the different pieces of the puzzle. They appreciated that the process had first got them to think more expansively to unpack all elements of the problem and then they were encouraged to focus on specific issues. While the process had given them more focus, participants felt they would need to work on selecting and developing ideas and planning for action before being able to make an accurate assessment of the practical value of ideas they had generated.

The group felt the ideas they had generated were either equally original or more original than in the last workshop. They reflected that they had started with the very broad question of how to increase profitability and then expanded on their understanding of that problem and its context and then narrowed it down to a set of problem statements. Now they felt that while the problem statements developed from the composite framing approach were all “great”, they should commit to a problem statement with some level of confidence that this is “the right one”. They agreed they should then spend more time seeking solutions to that particular problem statement—even if this took them four days. Participants felt they needed a structured approach to guide them through the process of determining which problem statement was most important, such that they could have the confidence to select a problem statement to which they could commit. They said that this would be “the icing on the cake”. They would also have liked to spend more time ideating.

Participants expressed appreciation that the process had clarified the problem and given them an aligned understanding, as at the outset they had all had their own 'gut feel' about the problem. This alignment had also made them more committed and focussed. A suggestion was made that additional stakeholders should be brought in to provide their input, especially for the purposes of planning for implementation.

The group was in agreement that going through the process made them more interested in the problem, more motivated to solve it and helped them to apply their minds in a more focussed, disciplined way.

Participants said they really liked the problem statements and thought they posed really good questions. They also agreed that the approach was effective in stimulating creativity. One reason given for this opinion was that "Now creativity can be more focussed". They found the approach easy to understand.

31.3.5 Analysis of feedback from focus group in Cycle 3

There was spontaneous mention that the process encouraged iterations of "expansion" in the interrogative information search, followed by "contraction" in the application of composite problem framing. This appreciation of the value of using divergent followed by convergent thinking is consistent with the theory (Isaksen & Treffinger, 2004; Sowden, Pringle, & Gabora, 2015) and also indicates that the normative framework facilitates these iterations.

While the methodology was designed to facilitate exploration from a multitude of angles, a need for focus was also expressed. Participants appreciated that several new perspectives were now available for them to explore, but felt they then needed to spend dedicated time exploring one specific problem statement. The depth of focus therefore appeared important to them. The value of composite problem framing in stimulating creativity was also seen to be related to its role in supporting more focus.

31.3.6 Feedback from personal interviews after Workshop 3

- 1. To what extent do you think the approach we used today might be helpful in improving your creative problem solving as a team?**
 - a. Any suggestions as to how the process could be improved to better support effective teamwork?**

Respondent 1: CIO

"The two aspects that stand out for me are the creative way of framing the problem and the structure that we used to try and come up with solutions – the DREAM TEAM. These are definitely useful when trying to optimise the performance of a team. The only challenge that I have is making sure we address the most important question (problem statement)."

Respondent 2: Business Improvement Engineer

"When the problem is broken up, when you change your perspective on the problem, when you understand the problem better, you can find better solutions. Doing it in a team, each person has a different perspective, so when you layer that on top of looking at the problem through this lens, then it brings in even more of a benefit."

"Stakeholders need to be brought in at different stages."

"Ideally this should be scheduled in two hour sessions with less time between meetings."

"Using more examples would help to explain how to work through the process, especially for the mind mapping (interrogative information search)."

Respondent 3: Business Improvement Manager

"I think the framing was very good. The DREAM TEAM is a good model but we need to spend more time after the DREAM TEAM to determine the way forward."

- 2. To what extent do you think the approach we used today might be helpful in improving your creative problem solving when working on your own?**
 - a. Any suggestions as to how the process could be improved to better support your individual creative problem solving?**

Respondent 1: CIO

"The DREAM TEAM structure is certainly something that could be easily used and this is quite a nice structure that can be used when working as an individual or as a team to get you to focus on different aspects. And the problem formulation did have you looking at things differently."

Respondent 2: Business Improvement Engineer

"Creativity becomes more focused because, whereas in a group you can leverage different perspectives, when you don't have those people you have to create those perspectives by breaking the problem up."

"I also think role playing can be used to see the problem from different stakeholders' perspectives."

Respondent 3: Business Improvement Manager

"On my own I could definitely use it. Especially the overall mind mapping (interrogative information search) and the DREAM TEAM. For big problems it's a very good model. I don't know if I would necessarily use it for a small problem."

3. To what extent has this approach to problem framing helped you to see your problem differently?

Respondent 1: CIO

"We've tackled a very broad problem statement as a whole and it's very daunting to tackle it at this level and now I think there are some problem statements we could tackle directly and probably find some solutions. Then there are some which kind of indicate that there is a gap in our understanding and our knowledge and we need to do the research in order to generate some direction. I think as soon as we have some direction, I don't think coming up with the solutions would be very difficult."

Respondent 2: Business Improvement Engineer

"It did. It helped us to see the link between the different problems because each problem is broken up into sub-problems."

Respondent 3: Business Improvement Manager

"In a group environment it allows feedback from everyone sitting around the table. When you can focus in on specific problem statements, it helps people to be aligned, as often we just go through the different angles very quickly."

4. Which (if any) specific aspects of this approach helped you to think of your problem differently or find a new angle or perspective on your problem?

Respondent 1: CIO

"Definitely the composite problem framing."

Respondent 2: Business Improvement Engineer

"The composite framing. One last step would be useful – to help us to decide which is the most important problem to solve first."

Respondent 3: Business Improvement Manager

"The DREAM TEAM helped to home in on different aspects of the mind mapping (interrogative information search). The expansion and then the contraction helped to make the problem much more tangible."

31.3.7 Analysis of feedback from interviews in Cycle 3

A A new appreciation for the importance of understanding the problem

One comment pointed to the appreciation of the pivotal role of problem construction, as it was mentioned that the interrogative information search had highlighted gaps in their understanding of the problem which, if filled, would enable solutions to be generated without much difficulty.

B Composite framing revealed new perspectives on the problem

Participants considered the process of combining concepts to produce composite problem frames to be relatively straight forward and claimed that they would use this approach on their own as well as in teams. There was general agreement that the composite framing approach helped them to see the original problem from different perspectives. The value of a structured process was reiterated.

31.3.8 Revisions to normative framework post Cycle 3

A Addition to composite problem framing: Process to select problem frames

A framework was developed to guide the selection of problem frames based on the priority level of the constituent concepts and consideration of whether the problem statements were already being addressed.

1. Rank concepts

- For Outcome, Obstacles, Enablers
 - 4 to 1 points according to priority (4 points for top priority)
- For Contextual factor and Comparable problem
 - 3 to 1 points according to priority (3 points for top priority)
 - Convert points for Contextual factors and Comparable problems as follows:
 - 3 becomes 4
 - 2 becomes 2.66
 - 1 becomes 1.33

Note: Points assigned differ for Outcome, Obstacles, Enablers versus Contextual factors and Comparable problems, as concepts from the former categories of concept are used in four composite problem frames whereas concepts from the latter categories are used in three composite problem frames.

2. Rank Problem Frames

- Add points from components of each problem frame to get a total priority score per problem frame
- Rank problem frames according to score
- For problem frames with equal scores, rank by subjective assessment

3. Select two to three problem frames

- From the highest ranking problem frames, select those which are currently not being addressed

B Addition to Problem Framing guidelines: Systemic Problem Framing Guidelines

1. Map relationships between key concepts using a causal loop diagram format or similar visual map
2. Circle a pattern of relationships that cause or perpetuate a problem
3. Formulate problem statement aimed at disrupting the pattern of relationships
Generic problem statement: *In what ways could this system be disrupted?*

31.4 Description and results of Cycle 4

31.4.1 Planning, action, observation and reflection conducted in Cycle 4

Planning in cycle 4: A session was planned to conduct creative problem solving on a second real business problem using elements of the revised normative framework where possible. The selected problem cannot be shared here to protect confidentiality.

Action in cycle 4: A workshop was facilitated in which team members were requested to conduct creative problem solving using an interrogative information search based on the revised approach to the interrogative information search framework as well as constructing a series of narrow problem frame based on the revised approach to composite framing.

Observation in cycle 4: Data was collected on the experience of using the revised normative framework. Such data was gathered both by direct observation and by requesting feedback from participants on their perceptions of the experience. Participants were also asked to complete the questionnaire on mediating variables after the focus group and interviews. Team members were asked to provide feedback on:

- i. the perceived effectiveness of the revised normative framework,
- ii. the perceived utility and originality of the solutions generated,
- v. frustrations encountered
- vi. constructive suggestions
- vii. any additional feedback on the process

Reflection in cycle 4: Data was analysed to gain insights into team members' experience of the refined normative framework. Where appropriate, this was used to fine tune elements of the framework as well as guidelines provided for using the framework.

31.4.2 Field notes from observation in Workshop 4

The same three participants who attended the third workshop were present. Completion of the interrogative information search proceeded more quickly than had been the case with the first problem and the participants appeared to have more confidence in progressing through the framework.

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Occasionally they skipped past certain questions but then subsequently came back to address these questions as they were found to be more relevant than previously assumed.

While this problem was one that the organisation had been working on for some time, certain issues raised had clearly not been raised in past discussions of this problem. One example of this was when it came to light that there could be resistance amongst employees to certain changes implied by addressing the problem. The comment was then made: “You see how important the framework is to ask the questions? We wouldn’t have thought about these things unless we were prompted.”

Certain concepts noted under Enablers, such as under the category of ‘additional insights regarding Obstacles’, could also be categorised under Obstacles, but it was agreed that as long as the relevant concepts were noted, where they were categorised didn’t particularly matter.

It was observed that while conducting the interrogative information search, all participants were engaged, sharing their own perspectives based on their experience. At one point the group called in a colleague from another department to give their input. The insights offered, highlighted additional opportunities to be harnessed.

The group were anxious to home in on one practical solution, and the facilitator reminded them of the need to look for a range of potential solutions in the ideation phase.

31.4.3 Analysis of field notes from Cycle 4

The speed with which the interrogative information search was completed may have increased due to practice in conducting this process, or due to the selection of a more narrowly focused initial problem frame.

The fact that skipped questions were subsequently addressed, appeared to endorse the relevance of the scope and range of questions in the interrogative information search framework. Another endorsement of the value of the framework was made when it was recognised that issues prompted by the framework had previously not been raised. As had been the case when conducting the interrogative information search on the first problem, the process highlighted gaps in understanding of the problem, such as the need to clarify the needs and priorities of certain stakeholders.

The discussion around whether certain concepts should be categorised as Enablers or Obstacles served to highlight that the same concept may play different roles in the problem, in that they can either be seen as an impediment or, if addressed in another way, may enable a solution.

In this case, the lack of specific information could have been seen as an obstacle, but accessing such information would be valuable in formulating a solution. A discussion about categorisation therefore enables problem solvers to see the same concept from a different perspective.

While it had not been the original intention behind the design of the interrogative information search, the process appeared effective at eliciting high levels of engagement as there were opportunities for all participants to submit their perspectives, all of which contributed to the overall appreciation of the problem.

The process of ideation, on the other hand, did not actively solicit input from all participants and some participants were more active in this process than others, with ideas being judged as they were submitted.

31.4.4 Focus group feedback after Workshop 4

One participant confirmed that he definitely thought the interrogative information search had revealed new insights into the problem, adding , “We’ve certainly had conversations today that we’ve never had before.” Other participants endorsed this view.

The group strongly agreed that the conceptual map was useful, as it highlighted priorities that they had identified. The visual representation helped them to see the problem more clearly.

Participants agreed that this approach helped them to keep an open mind. They would have liked more time to explore all the questions more fully, especially by asking for input from different stakeholders. There was agreement that the process encouraged debate. Participants reiterated that they had engaged in debates they hadn’t had before because of the question posed in the interrogative information search.

There was agreement that the composite framing approach was useful, as after all the concepts had been listed, priorities became clearer, and these flagged concepts were then reflected in the narrow problem frames. They appreciated this level of focus and the new angles this problem framing approach exposed, saying, with reference to the questions posed by the problem statements: “We’ve never thought to ask some of these questions before. That’s for sure.” This encouraged them to consider whether they needed to take another look at how they had been approaching the problem, such as by re-examining what formed part of the problem and what was outside the scope of this problem. The group found the process of developing composite frames simple enough to follow.

To assess the practicality of proposed ideas, they felt they would need to have developed action plans based on the ideas they had come up with.

Participants said that they would use this approach again. They appreciated that they needed to dedicate more time to the process, and suggested that the workshops should be shorter, but that there should be more of them. More stakeholders could also be brought into specific workshops. This scheduling approach would also be a practical way of tackling each of the narrow problem frames in turn. Another comment was that, while appreciating that there were many different aspects to a problem, they would like a way of ringfencing a certain part of the problem, and deciding on specifically what needed to be done, before exploring different ways of doing it.

31.4.5 Analysis of feedback from focus group in Cycle 4

When tackling sub-problems within broad, complex problems, frustration was expressed that solutions sought may be based on objectives that shift like moving targets. The reason for this is that if all sub-problems are interdependent, then if the desired outcome of one sub-problem changes, so do the desired outcomes of other, related sub-problems. Such frustrations will inevitably emerge when there is incomplete appreciation of the systemic nature of the problem, as this implies that each sub-problem cannot be addressed discretely. Recommendations to address this are provided in Section 33.4.

31.4.6 Feedback from personal interviews after Workshop 4

Only two participants were available to be interviewed after the fourth workshop.

- 1. To what extent do you think the interrogative information search and composite framing we used today might be helpful in improving your creative problem solving as a team?**

Respondent 1: Business Improvement Engineer

"We went through the process more quickly than before as we were more familiar with the methodology. This helps to make the process of greater practical value for us. One of the main advantages of using this process in a team was that it raised debate."

Respondent 2: Business Improvement Manager

"It would have been very difficult without facilitation. We needed strong facilitation of the discussion. We were all able to express what we wanted to, so the team size worked well. I would say the team shouldn't be too big and the ideal would be around five to six people."

2. **Are there any changes you'd suggest to the interrogative information search and composite framing to make it more effective when you use it as a team?**

Respondent 1: Business Improvement Engineer

"Workshops could be shorter. A maximum of three hours would work well. While we were familiar with the process now, more training and going through the whole process step by step could have been useful."

Respondent 2: Business Improvement Manager

"We could divide the team up to tackle different issues. A small team, or even just two people could work on different sections and then contribute to the overall interrogative information search. Two people could work better than one person working on their own as the dialogue would be useful."

3. **To what extent do you think the interrogative information search and composite framing we used today might be helpful in improving your creative problem solving when working on your own?**

Respondent 1: Business Improvement Engineer

"I would use composite framing on my own as this really helps to see the problem from different perspectives. I might not do the interrogative information search on my own as this takes a long time. "

Respondent 2: Business Improvement Manager

" I would do the interrogative information search on my own but probably not with the same level of rigour as I would do it in a team. I would also use the DREAM TEAM. But really I think one needs all the components."

4. **Are there any changes you'd suggest to the interrogative information search and composite framing to make it more effective when you use it on your own?**

Respondent 1: Business Improvement Engineer

"I'd like to learn how to develop action plans. "

Respondent 2: Business Improvement Manager

" Rather than using it on my own, I'd prefer to work with a partner. While I did suggest an app before, I'm not sure now how that would work."

31.4.7 Analysis of feedback from interviews in Cycle 4

A Enablers of team creative problem solving

Factors that supported the effectiveness of creative problem solving as a team were thought to be the familiarity with the process, the small team size and strong facilitation.

The need for both a structured approach and strong facilitation emerged through all four workshops. However, before working through the normative framework for the second time, only a brief overview was provided as a refresher, as the group appeared comfortable with the process and did not have questions about how to work through the normative framework.

B Lengthy team workshops facilitated rigour but taxed concentration

Because the phased approach of this action research required that the different stages in the normative framework were implemented and tested over four workshops, workshops were scheduled to run over three to four hours each. Some participants found it challenging to maintain focussed concentration during the longer workshops, and while focussed, disciplined thinking over an extended period of time may be conducive to creativity (Amabile, 1983; Richards, 2010) this may well need to be balanced against personal limitations (see Section 33.3 below).

The feedback from participants that they would work through different components of the normative framework on their own is an endorsement of their perceived value of the framework. Yet clearly elements of rigour would be lost if the individual were to work independently. This is related to the previous point regarding limitations to attention spans. It is suggested that this is a challenge that needs to be acknowledged and addressed, given the positive role of restricted attention and deep concentration in creativity (Csikszentmihalyi, 2014).

31.4.8 Responses to questionnaire on mediating variables after Workshop 4

As there were only three respondents to this questionnaire, the data did not lend itself to statistical analysis. Therefore responses have been analysed qualitatively.

All participants believed that they had more complex mental models of the problem after using this normative framework, with only one participant rating one of the five statements as 'the same as before'.

Cognitive flexibility increased for all participants, especially with regard to exploring different perspectives and potential solutions, although given the time constraints there was little opportunity to evaluate the impact of potential solutions.

The response that stands out with regard to intrinsic motivation is that after using this approach all three participants were more or much more interested in spending time trying to solve this problem than they had been before. Two of the three respondents also prioritised this problem much more than before.

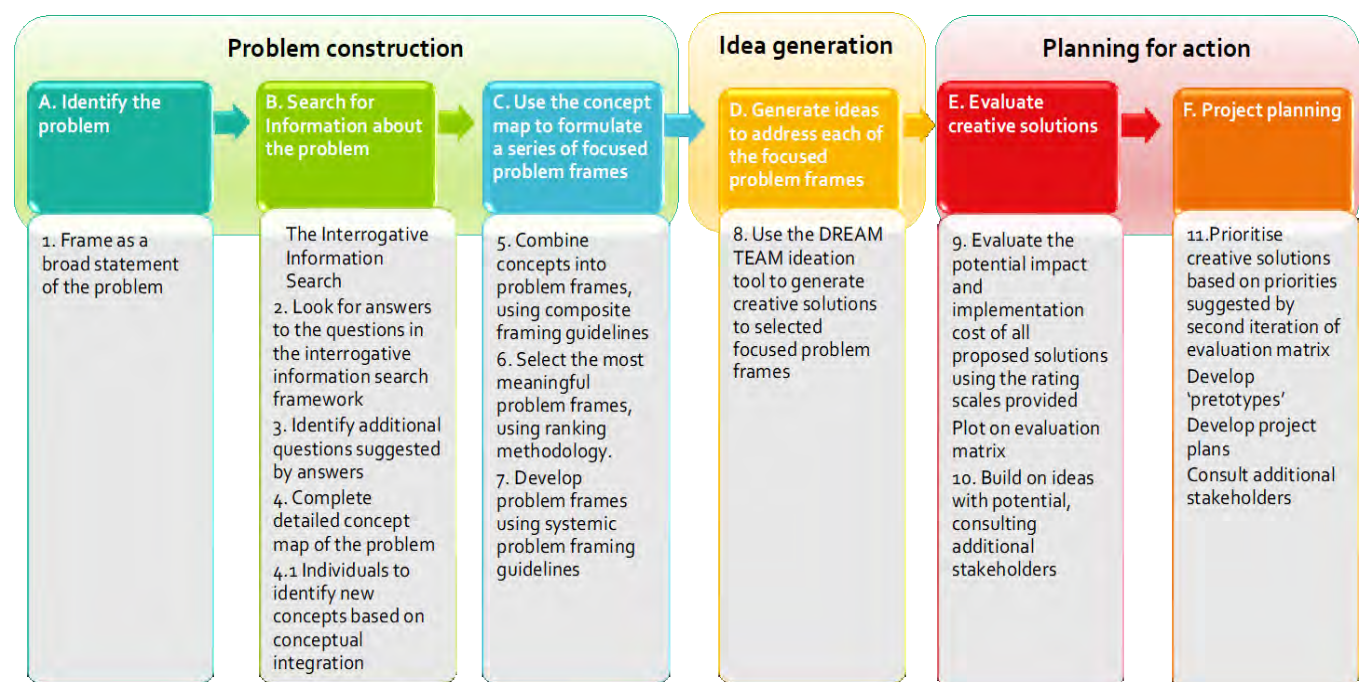
Although there was some variation in participants' ability to concentrate fully on the problem for the duration of the workshop, responses to the items in the cognitive persistence scale indicated that all believed they had extended their thinking beyond the superficial and pushed their thinking beyond their previous boundaries.

32 REVISED NORMATIVE FRAMEWORK

The normative framework that includes revisions from this study are included in Figure 23 below, following which steps are described in detail.

Figure 22

Revised normative framework post action research



A. Identify the problem

Step 1: Develop initial broad problem frame

Initially, the problem should be framed using a broad problem statement. This broad view should then be discussed to provide an overview of the problem.

B. Search for Information about the problem

At least three workshops of two to three hours each should be scheduled to conduct the interrogative information search.

Development of an app

The feasibility of developing an app of the interrogative information search framework with prompts to facilitate progress through the questions, should be investigated.

Step 2: Look for answers to questions in interrogative information search framework

Look for answers to questions posed in the interrogative information search Draft 7 (see Appendix C) using the following guidelines:

Guidelines for using the interrogative information search

- a. Proceed through the sequence of answering questions regarding,
 - The desired Outcome
 - Obstacles
 - Enablers
 - The Context
 - Analogies/ Comparable problems
- b. If pondering latter questions evokes thoughts on questions already considered, go back to these questions and provide the relevant responses. Then resume reflecting on questions as per the sequence.
- c. Not all questions may be relevant, but if at first a question appears not to be relevant to the problem being addressed, attempt to probe whether this is the case before moving on to the next question.
- d. Not all questions deserve equal attention for your problem. While some questions do need further consideration, even if at first they do not appear overly relevant, focus on answering the questions that you find most interesting and provocative.
- e. Responses to certain questions may require further research. Not all questions need to be answered immediately.
- f. Responses to questions should be documented in a concept map based on the same format as the interrogative information search framework.
- g. When particularly useful insights are noted, they should be flagged as high priority concepts on the concept map.

- h. In the process of developing the concept map, it may be noted that the initial broad problem statement needs to be reframed. In this case, a new concept map should be developed.
- i. All relevant stakeholders should be canvassed to provide input to answering questions and completing the resultant concept map of the problem. Such stakeholders may or may not be part of the creative problem solving team. Individuals conducting creative problem solving on their own should also consult broadly to elicit input on responding to questions in the interrogative information search framework
- j. When completing the interrogative information search as a team, individual accountability may be allocated to team members for searching for relevant responses and additional questions regarding different aspects of the interrogative information search framework.
- k. If the framework is to be used without a facilitator, explanatory notes will be included with certain questions.

Step 3: Identify new questions

Identify additional questions that may emerge in the course of searching for and formulating answers to questions in the interrogative information search framework.

Step 4: Complete detailed concept map of the problem

The resultant concept map should be reviewed to ensure that it provides a complex model of the problem that includes

- relevant concepts
- relevant relationships
- flagging of priority concepts

Step 4.1: Individuals to identify new concepts based on conceptual integration

- Individuals, acting independently, are to review concepts in each of the five categories in the conceptual map and ask themselves the following question: "Which concepts in this category can be combined such that a new emergent concept can be identified?"
- When creative problem solving is being conducted as a team, individuals should then report back to the team on the newly identified concepts and these should be incorporated into the conceptual map.

C. Formulate series of focused problem frames

Step 5: Combine concepts into problem frames using composite framing guidelines

Composite framing guidelines constitute a practical approach to enable conceptual combination, drawing on priority concepts flagged in the concept map of the problem.

Composite framing guidelines

1. Combine concepts from Outcomes and Obstacles

Generic problem statement: *In what ways could this outcome be achieved by avoiding or overcoming this obstacle?*

2. Combine concepts from Outcomes & Enablers

Generic problem statement: *In what ways could this resource be used to address the needs of this stakeholder?*

3. Combine concepts from Outcomes & Context

Generic problem statement: *Given this contextual element, in what ways could this stakeholder's needs be addressed?*

4. Combine concepts from Outcomes & Analogies

Generic problem statement: *In what ways could we emulate how this outcome has been achieved by others in this analogical situation?*

5. Combine concepts from Obstacles & Enablers

Generic problem statement: *In what ways could this obstacle be addressed by drawing on this resource?*

6. Combine concepts from Obstacles & Context

Generic problem statement: *Given this contextual element, in what ways could this obstacle be addressed?*

7. Combine concepts from Obstacles & Analogies

Generic problem statement: *In what ways could learnings from this analogical situation be harnessed to overcome this obstacle?*

8. Combine concepts from Enablers & Context

Generic problem statement: *Given this contextual element, in what ways could this resource be better leveraged?*

9. Combine concepts from Enablers & Analogies

Generic problem statement: *In what ways could we emulate how this resource has been leveraged by others in this analogical situation?*

Step 6: Select the most meaningful frames

A series of problem frames should be selected from those generated and addressed sequentially by using an ideation technique to generate potential creative solutions to each problem frame.

Process to select problem frames:

1. Rank concepts

- For Outcome, Obstacles, Enablers
 - 4 to 1 points according to priority (4 points for top priority)
- For Contextual factor and Comparable problem
 - 3 to 1 points according to priority (3 points for top priority)
 - Convert points for Contextual factors and Comparable problems as follows:
 - 3 becomes 4
 - 2 becomes 2.66
 - 1 becomes 1.33

Note: Points assigned differ for Outcome, Obstacles, Enablers versus Contextual factors and Comparable problems, as concepts from the former categories of concept are used in four composite problem frames whereas concepts from the latter categories are used in three composite frames.

2. Rank Problem Frames

- Add points from components of each problem frame to get a total priority score per problem frame
- Rank problem frames according to score
- For problem frames with equal scores, rank by subjective assessment

3. Select two to three problem frames

- From the highest ranking problem frames, select those which are currently not being addressed

Step 7: Systemic Problem Framing Guidelines

1. Map relationships between key concepts using a causal loop diagram format or similar visual map
2. Circle a pattern of relationships that cause or perpetuate a problem
3. Formulate problem statement aimed at disrupting the pattern of relationships

Generic problem statement: *In what ways could this system be disrupted*

D. Generate ideas to address each of the focussed problem frames

Step 8: Use DREAM TEAM ideation technique

For idea generation, the DREAM TEAM ideation technique has been employed. This technique was developed for the purposes of the experiment, and was found to be effective by participants. This approach was modelled on the SCAMPER ideation technique, in that it requires the problem solver to consider a series of alternative ways of addressing the problem (Eberle, 1996; Osborne, 1957).

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This series of mental operations is described by the acronym, DREAM TEAM, based on the first letter of the description of each operation. These operations are described in Figure 24 below.

Figure 23

DREAM TEAM ideation technique

Diminish or Downscale Are there parts of the problem you can diminish or downscale?	Tailor Are there parts of the problem you can tailor to address specific needs/ purposes/ people?
Resourcing Could you consider alternative resources for managing the problem, such as by outsourcing or partnering with others?	Emulate Are there examples of how this challenge or similar challenges have been addressed by others that you can learn from and emulate?
Extract Are there aspects of the problem that can be extracted or eliminated?	Automate Is there a way you can harness or make better use of technology ?
Add Is there a new element you could add or introduce to combine with existing elements?	Make Magic What can be done to add a spark of something special ?
Magnify Could you magnify or exaggerate any aspect(s) ?	

E. Evaluate creative solutions

Step 9: Evaluate proposed solutions

The potential impact and implementation cost of all proposed solutions generated in the ideation phase are to be evaluated using the following evaluation criteria and rating scales:

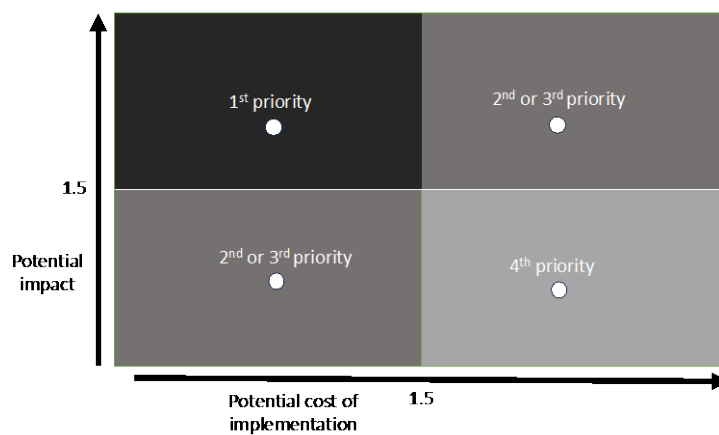
IMPACT EVALUATION CRITERIA	RATING (1 = Low/ 2 = Med/ 3 = High)
Extent to which priority issues are addressed	
Long term sustainability of impact	
Benefits to stakeholders	
Average Rating	

COST EVALUATION CRITERIA	RATING (1 = Low/ 2 = Med/ 3 = High)
Direct financial cost	
Resource intensity	
Time to implement	
Potential for disruption	
Average Rating	

Proposed solutions should then be mapped onto the evaluation matrix in Figure 25.

Figure 24

Evaluation matrix for proposed creative solutions



Each solution's position on the evaluation matrix will inform whether they should be selected and further developed.

Step 10: Build on ideas with potential

Based on their position in the evaluation matrix, ideas should be selected for further development. Such development could take place by using the Six Thinking Hats to explore each idea's potential (De Bono, 1992). Once ideas have been further developed, they may be re-evaluated. The potential impact and costs can then be re-evaluated and plotting on the evaluation matrix may be revised.

A broad range of stakeholders should be consulted to provide input into building on ideas with potential and considerations for project planning and implementation. This may include individuals external to the organisation.

F. Project planning

Step 11: Prioritise creative solutions, test through the use of 'pretotypes' and develop project plans

- Plan timing for implementation of priority ideas suggested by second iteration of evaluation matrix and rank according to urgency.
- Identify stakeholders who need to buy in to the idea and those responsible for implementation and ask for input to assist in scenario planning. Communicate benefits and share plans of alternative scenarios to gain commitment of key stakeholder groups (Seelig, 2015).
- Develop 'pretotype' in the form of a rough facsimile of the end product to test the viability of the concept before full scale development (Seelig, 2015).
- Develop detailed project plans delineating timelines, resource requirements and accountabilities.

33 DISCUSSION AND RECOMMENDATIONS

33.1 Increase in both understanding and curiosity

This study confirmed that the interrogative information search supported a broader and deeper understanding of the problem, with participants frequently alluding to the role that the questions in the framework played in prompting them to ask questions about the problem that they would not have considered prior to using this framework. It is interesting to note here, that this renewed interest in the problem was achieved despite familiarity with the problem, which Reiter-Palmon et al. (1997) suggested could create resistance to considering alternative perspectives. Coupled with this increase in understanding was the appreciation of the importance of understanding in the creative problem solving. As some participants said, they feel they usually jump into looking for solutions too quickly and should spend a lot more time exploring the problem.

In addition, the role of the interrogative information search in supporting curiosity about the problem was also confirmed, as subjects reported being interested in spending a lot more time unpacking and solving the problem. Participants' comments also revealed an increase in their level of doubt regarding their prior understanding of the problem. These included comments such as "No-one knows. We haven't done this research. We need to do this research...".

This was an important finding in endorsing the intended impact of the normative framework, as the objectives of this framework included not only the development of an extended conceptual map of the problem, but also a shift in the approach of problem solvers such that they would generate their own momentum in solving the problem by virtue of their enhanced curiosity.

33.2 The need for structure

Participants in this study frequently referenced the need for a structured approach to creative problem solving. This was evident from responses to interviews in the first cycle and persisted throughout all four cycles, in which participants cited a structured approach as a critical success factor in ensuring that the right issues would be addressed. In fact, even when faced with the choice of nine composite frames, participants requested a structured process to facilitate the selection of the two to three problem frames they would address.

When seen against the background of observations from the first workshop, in which attempts to unpack the problem were found to be frustrating as the team felt they were not breaking new ground, it can be inferred that structure is required to navigate the complexity of unbounded problems.

This inference is supported by comments made in the focus group in Cycle 2, in which the team expressed relief at having a roadmap to follow, with the process having a “beginning and an end” such that they could see where they were in the process. It is suggested therefore, that one of the key advantages of a structured approach to creative problem solving is that it enables a sense of progress necessary to maintain motivation in working through the problem.

While it was not the intention to specifically explore the team’s experience of using the DREAM TEAM, participants repeatedly mentioned that this was a technique they found valuable and would use on their own. Again, the structured approach of the DREAM TEAM was mentioned as one of the reasons for its value, and it was compared favourably to the lack of structure in a brainstorming approach. Comments related to the use of the DREAM TEAM and the interrogative information search suggest that another reason that structure is preferred is that it imposes a level of rigour, directing thinking and ensuring that new perspectives are probed.

33.3 Cognitive persistence is motivated by cognitive activation

As commented on in Paper 1, cognitive persistence is an essential ingredient of creativity, as succinctly indicated by the quote “Perhaps the single most reliable finding in our studies is that creative work takes a long time” (Gruber & Davis, 1988, p. 264, as cited in Baer, 2015).

In this study, participants found the long workshops challenged their ability to focus, yet despite occasional protests at the mental exertion they had to expend, they expressed interest in working through the process for three to four days. Therefore, while working through the normative framework, and especially the interrogative information search, is time consuming and cognitively demanding, participants were sufficiently engaged to motivate interest in extending time spent on the process. This aligns with the argument that the cognitive activation of working towards the achievement of unmet goals plays a more significant role in supporting creativity than a positive mood (Baas, De Dreu, & Nijstad, 2011; Baas et al., 2008; Carver, 2004; Frijda, 1986; Izard & Ackerman, 2000; Reisenzein, 1994; Watson et al., 1999).

Of course, while cognitive persistence is required to maintain concentration and ‘break set’ for creative breakthroughs (Amabile, 1983; De Dreu & Nijstad, 2012; Weisberg, 2006), it is important to manage the risk that problem solvers are not forced to extend their cognitive efforts to the point of disengagement. It has been found that conducting the interrogative information search will take at least six hours, and sufficient time needs to be allocated to this and the rest of the process. Therefore, while it may not be ideal for the purposes of ‘breaking set’, it is likely to be beneficial to schedule a series of shorter workshops, perhaps extending to no longer than the three hours suggested by one participant.

33.4 Accommodating the need for focus while maintaining appreciation of complexity

According to feedback from action research participants, the interrogative information search was successful at promoting curiosity about the problem, and responses to questionnaires endorsed the ability of the process to develop more complex mental models. A complex mental model that supports effective creative problem solving should include both numerous concepts as well as the relationships between them (Hester et al., 2012; Malaycha & Maier, 2017). Participants expressed appreciation that as the parts of the problem had been clarified, it was less daunting to tackle. They found, therefore, that the depiction of a range of concepts suggest multiple points of entry into the problem. However, over time, as the team developed their understanding of the relationships between concepts, it became clear that parts of the problem could not be addressed in isolation. The appreciation of the complexity of the problem came at a cost therefore, as the team became frustrated with the challenge of managing the systemic nature of different aspects of their problem.

The composite framing assisted the clearly expressed need for focus by enabling the team to home in on narrowly focused sub-problems and the composite problem framing approach posed questions in the form of problem statements that had not previously been posed. However, understanding the complexity of the problem made it harder for the team to select the two or three composite frames to be used in the ideation stage, as they understood the relationships between these sub-problems. This was addressed by the development of guidelines to assist in the selection process.

This finding supports the theory that cycles of convergent and divergent thinking are required in creative problem solving (Isaksen & Treffinger, 2004), and perhaps that the greater the divergence, the greater the need for facilitation of convergence such that appreciation of the complexity of the problem does not become overwhelming. The requirement for the focused attention of convergent thinking and the open exploration consistent with divergent thinking is indeed cognitively demanding, which may be addressed by taking sufficient breaks, as discussed above, as well as alternating between the two modes.

However, it is important to maintain this appreciation of complexity and relationships between sub-problems in order to avoid fixation (Rietzschel et al., 2006) and the risk of drawing aspects of the context into the solution (Ward & Kolomyts, 2010). (See discussion in Section 6.7.3 of Paper 1). While certain participants expressed a preference for selecting only one problem frame, addressing a series of composite frames better expresses the complexity of the broad problem as overlaps and dependencies between composite frames are appreciated.

Potential implications of a reductionist approach should be clarified by exploring and expressing the inevitably systemic nature of complex problems, which do not lend themselves to dissection into discrete sub-problems (Mingers & White, 2010; Senge, 1990).

The assumption that only one sub-problem can be addressed while other related sub-problems are held constant, must be challenged, as solutions to sub-problems will inevitably have consequences - delayed or otherwise - on related sub-problems (Senge, 1990). It is therefore recommended that the systemic nature of problems and their network of casual relationships is fully explored and expressed prior to ideation.

A range of approaches may be drawn on to support the development of this systems perspective. Soft systems methodology, for example, is extensively used to facilitate systems thinking (Mingers & White, 2010). Importantly, the web of causal relationships and dependencies should be clearly incorporated in the concept map. This is likely to support the development of more sophisticated mental models that facilitate the production of more creative solutions (Hester et al., 2012). The depiction of reinforcing or positive loops and balancing or negative loops in the concept map can also be used to ensure that the systemic nature of the problem is appreciated (Mingers & White, 2010). This understanding of the systemic nature of complex problems may then be expressly harnessed to manage expectations that sub-problems can be addressed in isolation.

33.5 Cognitive persistence is required to reinforce cognitive flexibility

Responses to focus groups, interviews and questionnaires indicated that working through the process increased cognitive flexibility, as new issues came to light due to questions encouraging participants to consider angles of enquiry they would otherwise have overlooked. This is an important benefit of the interrogative information search, as the inability or reluctance to explore new angles of a problem is often responsible for failures in creative problem solving (Mumford et al., 2020).

In this action research however, there appeared to be a strong leaning towards practical solutions that pose a low risk. This mitigates against more original solutions which are, by implication, more risky. This is in keeping with the findings of Mumford et al. (2020). It was found therefore, that the team tended to home in and build on solutions they had already considered. This was especially true in the first workshop before the application of the normative framework, but while this tendency persisted when working through the normative framework, both the interrogative information search and composite framing did, according to participant feedback, provoke new angles of enquiry and the cognitive flexibility to entertain new ideas.

It is recommended however that, as this openness to the original is likely to be subverted to the dominant tendency to find safe, predictable solutions, problem solvers need to be encouraged to follow through in looking for more original solutions in the ideation phase and in planning for action. This requires both time and cognitive persistence as the more original solutions are likely to only emerge after extended effort. (Dreisbach & Goschke, 2004; Koch et al., 2008; Nijstad et al., 2010; Rietzschel, Nijstad, & Stroebe, 2014).

This need for both cognitive flexibility and cognitive persistence was stressed in the premise for the development of the concentrated curiosity model in Paper 1, and results of this study provide further support for the argument that cognitive persistence is needed to extend thinking beyond the practical rather than original solutions that are likely to emerge in initial stages of ideation.

33.6 The value of teamwork and potential for working in pairs

As commented on in Section 4.5 of Paper 1, the focus of the concentrated curiosity model is to facilitate curiosity at an individual level, both because individuals have been found to solve problems more creatively than teams (Boh et al., 2014; Diehl & Stroebe, 1987; Dennis & Valacich, 1994; Mullen, Johnson, & Salas, 1991; Mumford, 2000; Taylor & Greve, 2006; Reiter-Palmon, Herman, & Yammarino, 2008), and addressing factors that influence team performance fell outside the scope of this thesis. It was, however, the intention to design a normative framework that could be used either by an individual or a team. It was therefore interesting that the preference for working through the framework as a team emerged as being more important than originally assumed by the researcher.

The multiple perspectives offered by team members were very important to participants and they reiterated the potential value of bringing in more stakeholders. This perspective is aligned with findings that collaboration supports creative breakthroughs (Sawyer, 2007), and that inviting interaction with colleagues from other functional areas and those with diverse perspectives also facilitates higher levels of creativity (Perry-Smith & Shalley, 2003). Furthermore, the value of integrating the perspectives of different stakeholders in a visual depiction of the problem was appreciated, as this reinforced the role of learning in the experience of completing the concept map (Checkland, 2000).

It was also acknowledged that stakeholders responsible for implementation of any solution needed to be involved in contributing to an exploration of the problem. Assuming that there is a unified view of a single desired outcome, for example, has been found to lead to a blinkered pursuit of a potential range of solutions and alienated those whose views are not entertained (Mingers & White, 2010).

When external stakeholders such as colleagues from other departments were asked to contribute to the interrogative information search, it became clear that their world-views were based on assumptions that formed part of the problem. The opportunity to explore alternative world-views through enabling broader participation in the process, clearly has value in the information search (Checkland & Poulter, 2020).

While the value of teamwork is appreciated however, it is maintained that the potential risks of teamwork should be actively be managed, based on extensive findings regarding the superior effectiveness of individual creative problem solving (Boh et al., 2014; Dennis & Valacich, 1994; Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991; Mumford, 2000; Taylor & Greve, 2006; Reiter-Palmon, Herman & Yammarino, 2008).

Working in pairs at different stages in the implementation, as recommended by one of the action research participants, might be an effective means of ensuring the collaboration and conversation needed to support the rigour required to work through the interrogative information search while at the same time creating conditions for greater individual accountability as well as leveraging the ability of individuals to combine knowledge more effectively than teams (Taylor & Greve, 2006). While, according to Runco (2010) even working in pairs may pose a slight risk to the individuals' creative potential, it is suggested that this compromise may be worth the potential benefits of increased rigour and accountability, which participants in this study said they might lack when working in their own.

It is recommended therefore, that when working through the interrogative information search, when questions cannot be immediately answered or when new questions are generated, responsibility for answering these questions should be allocated to pairs of participants who could report back to the next workshop with the team. It would be important for the team to discuss the contributions of pairs, as the expanded view of the concept map of the problem should be shared. This approach could enable delving into issues that require further exploration, and iterating between working as pairs and working as a team could harness the benefits of both modes (Taylor & Greve, 2006).

Ultimately therefore, due to the reasons described above, implementation of the normative framework might benefit from a blend of problem solvers working as individuals, pairs and teams.

33.7 Recommendations for future practice and research

33.7.1 Integrating critical and creative thinking

As the interrogative information search includes the highlighting of issues currently not being optimally managed, it is to be expected that participants may at times become defensive. The process of creative problem solving risks exposing participants to judgement and critique – both when exploring factors underlying problems in an organisation and in ideation, when sharing untested ideas. While one of the traditional rules of brainstorming attempted to limit judgement to after idea generation (Osborne, 1963), research indicates that exercising judgement and critical thinking while ideating may actually be more effective than postponing the critique (Nemeth, Personnaz, Personnaz, & Goncalo, 2004). As commented on above, cycling between convergent and divergent thinking is an essential feature of the creative problem solving process and it appears that problem solvers naturally alternate between modes of thinking. It is therefore difficult, and as Nemeth et al., (2004) found, probably not optimal to separate out judgement or critical thinking from the creative problem solving process.

As creative solutions need to be effective, reasoning and judgement applied to the assessment of the solutions utility needs to be integrated into the process. Two alternative approaches are possible: firstly, time could be allocated for specifically delineated opportunities for critiques at particular points in the process. The second option is to integrate critical and creative thinking into a coherent process, as creative performance requires the interplay between convergent and divergent thinking (Runco, 2006). It is recommended that potentially greater value can be derived from the latter approach, both because trying to isolate reasoning from the generation of original ideas may be overly contrived (Runco, 2006), and because, as argued in Section 5, the view of creativity which informs the concentrated curiosity model is that creative thinking is not a nebulous, ethereal phenomenon but incorporates reason and rigour.

33.7.2 Action research to refine normative framework for planning for action

Action research workshops were designed to focus on problem construction and the ideation based on this, in order to determine the value of the approach to problem construction. However, it was clear that participants would have also liked to engage in the third stage of planning for action. This would also have given participants a greater sense of the originality and utility of the ideas they had generated. While the objectives of this action research study did not include the evaluation of the effectiveness of the approach to planning for action included in the normative framework (see Stages E and F), further research should be conducted to determine and enhance the value of these approaches.

33.7.3 Exploring the role of facilitation and potential for an app

In the focus group and interviews after the first workshop in which the normative framework was not yet implemented, participants expressed a need for structure and facilitation in the creative problem solving process. Facilitation was used to explain the process, prompt responses to the interrogative information search, suggest priorities based on discussions, suggest possible composite problem frames and prompt responses to the ideation process. Feedback received in interviews and focus groups was that this facilitation was very important to the success of the process.

While facilitation was therefore clearly valuable to the group in ensuring adherence to the interrogative information search process and a level of rigour in developing the concept map, it is important to acknowledge the potential pitfalls of active facilitation. When facilitation migrates from process and content management into the substance of the problem, problem solvers may find such intervention valuable, but may also feel less sense of ownership of the outcomes (Ackermann, Franco, Rouwette, & White, 2014).

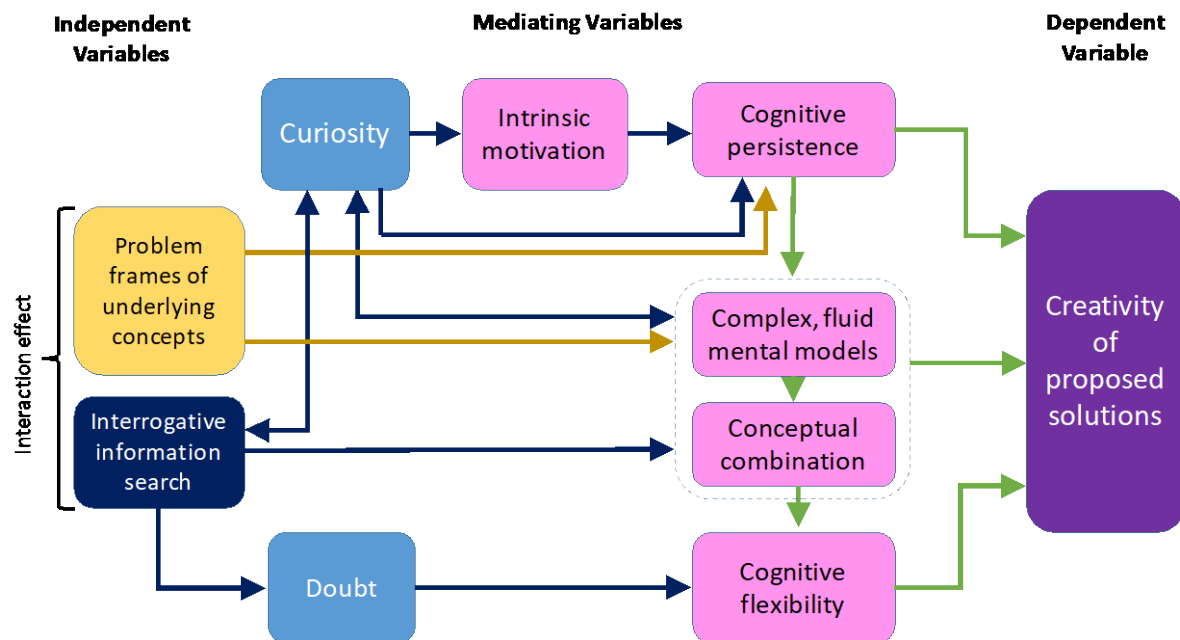
Against this background, there was an early suggestion that an app of the normative framework could be developed, but after the last workshop, when asked about this again, this participant was not sure how well this would work. The suggestion of developing an app was also made in a number of the interviews conducted as part of the development of the normative framework (see Paper 3) This is an interesting consideration that needs to be informed by the degree of facilitation required. Further research should therefore explore how effectively the normative framework could be used by problem solvers without facilitation, once participants have been trained on how to use it. It would also be interesting to explore the extent to which artificial intelligence could be harnessed to prompt responses, taking into consideration the context, industry and prior responses.

34 CONCLUSIONS

The aim of the normative framework was to provide a structured series of steps to implement the concentrated curiosity model, repeated below in Figure 26.

Figure 25

The concentrated curiosity model



Feedback from the first cycle in this study supported the contention that simply following a process model in which participants worked through the three stages of the CPS process did not enhance the perceived effectiveness of creative problem solving, confirming the need for detailed guidelines and the normative framework.

As stated in Section 30.5 above, a comparative analysis was conducted in this study to determine the extent to which participants' experience of implementing the normative framework aligned with expectations, namely that it would engender

- increased curiosity about the problem,
- development of more complex mental models of the problem,
- increased intrinsic motivation to solve the problem,
- improved cognitive flexibility by asking new, previously unexplored questions about the problem,
- the ability to home in on specific relevant issues, and
- enhanced ability to apply cognitive persistence to solving the problem.

Findings indicated that the use of the normative framework to implement the concentrated curiosity model was effective in stimulating curiosity about the problem, as action research participants attested to feeling both more curious about the problem and wanting to investigate it further, suggesting increased intrinsic motivation. The increase in intrinsic motivation was also supported by responses to the questionnaire. The fact that the group elected to include an additional three hour workshop to work through the interrogative information search, further supports this assertion. As participants questioned their previous understanding of the problem, this also raised doubts about their prior appreciation of its complexity and approaches adopted to addressing it.

Feedback from focus groups and interviews as well as from questionnaire responses indicated that the normative framework enabled the building of more complex mental models which was supported by the inclusion of more concepts and the specification of a rich network of relationships between the concepts (Hester et al., 2012; Malaycha & Maier, 2017). Conceptual combination was actively applied in the composite framing, as concepts within concept maps were used in different combinations in the composite frames, such that novel problem statements were posed. Cognitive flexibility was also enhanced as participants agreed that they were asking questions about the problem and considering perspectives that they never had before.

Some support for the increase in cognitive persistence was suggested by the interest in spending an extended period of time in latter workshops dedicated to answering questions that emerged while working through the interrogative information search. This supported the argument that curiosity evoked by the approach would increase cognitive persistence. As mentioned in Section 33.5 above, scheduling of shorter workshops with a maximum of three hours duration is likely to ensure that problem solvers are able to maintain focussed concentration.

A review of the literature has not revealed any other approach to an iterative information search that focuses on continually broadening and deepening appreciation of the problem space. Application of this normative framework elicits cognitive flexibility by encouraging the problem solver to approach the problem from new perspectives. This approach to the information search within problem construction is therefore a key differentiator. In addition, while sequential framing is proposed in the literature, the composite framing process that generates the series of narrow frames is distinctive, as it also offers a structured, systematic approach to facilitate conceptual combination.

In conclusion therefore, it is asserted that the normative framework outlines a novel and effective process for optimising the creative problem solving and that this provides both a theoretical and methodological contribution to the literature.

OVERVIEW OF THE FOUR PAPERS

35 SUMMARY OF FINDINGS AND CONCLUSIONS

With problem construction being arguably the most impactful stage in the creative problem solving process, a novel theory was developed in Paper One to explain how specific approaches to problem construction could enhance the creativity of ideas subsequently generated. This theory posits that employing a search that focuses on generating questions, referred to as an interrogative information search, and by constructing a series of narrow problem frames that draw on the concepts that emerge from the interrogative information search, will result in the generation of more creative solutions. Proposed relationships between the independent and dependent variables were explained by incorporating mediating variables of cognitive flexibility, cognitive persistence, intrinsic motivation and complexity of mental models. The theory posited that the interrogative search and working with narrow frames of underlying concepts would have a positive impact on these mediating variables both directly as well as through evoking states of curiosity and doubt. A model of this theory was then developed to depict the proposed predictive relationships.

Then theory was then tested empirically in Paper Two. Hypotheses emerging from the theory and model were then tested through an experiment that lent support to the theory. Specifically, an interrogative information search and narrow problem frames were associated with a greater increase in creativity than a factual search or a broad problem frame. Findings from the analysis of the sub-scores of utility and originality also indicated that originality and utility increased significantly only when the frame was narrow rather than broad, or when the search was interrogative rather than factual.

Results of the analysis of mediators did not indicate that they played a role in explaining the relationship between the independent variables and the dependent variables. The limited sample size may in part be responsible for the lack of significant findings in this regard. However, it is noteworthy that complexity of mental models was the dimension found to have increased the most under experimental conditions, and this dimension did have a significant relationship with the increase in creativity, and specifically, with the increase in the sub-score of originality.

In the experiment, while instructions were given as to how to conduct an interrogative search, it was found from qualitative analysis of questions generated, that participants in the experiment required more guidance in formulating questions.

OVERVIEW OF THE FOUR PAPERS

The normative framework developed in Paper Three was designed to provide a detailed set of guidelines for the practical application of the theory, incorporating empirical findings that supported the theory as well as certain unexpected findings, such as the result that when the combined relationship of variables was tested, the Broad Interrogative group exhibited the greatest increase in the creativity of solutions. Addressing the finding that experimental participants were not able to effectively follow the instructions for the interrogative search was a priority in the development of this framework. After a first draft framework of questions was developed, in-depth interviews with individual problem solvers from different industries were used to iteratively enhance the value and relevance of the questions. The aim was to ensure that the questions were sufficiently generic to apply across diverse problems and contexts, while being sufficiently probing to unearth previously unexplored aspects of the problem.

The objective of the normative framework's approach to problem framing – namely composite framing – was to both formulate a series of narrow problem frames and to facilitate conceptual combination by combining concepts from the conceptual maps generated from the interrogative search. Guidelines with respect to concepts that could be combined were gleaned from discussions in the interviews.

In Paper Four, the normative framework was tested through action research. It was found that the normative framework was effective in helping participants to consider previously unrevealed aspects of the problem. More specifically it had the effect of stimulating interest in and curiosity about the problem, enhancing willingness to exercise cognitive persistence, thereby also enhancing cognitive flexibility, and supporting a balance between focus and appreciation of complexity. Research participants also appreciated the structured approach. Additional insights gleaned, such as the resultant cognitive fatigue and the need to invite new perspectives from additional stakeholders, were used to supplement the normative framework.

36 SUMMARY OF KEY LIMITATIONS

While the literature review aimed to identify and incorporate all salient research, the specific focus of the literature search was on the role of and approaches towards the information search and problem framing, as well as the desired end states of problem construction and the cognitive processes elicited from these. As this was a purposeful search, depth was at times favoured over breadth of literature reviewed.

A limitation of Paper Two is that as a small sample size may constrain the ability of more sensitive analytical techniques to detect significant differences in the data, results of the application of these techniques yielded limited significant findings. The small sample size may also limit the ability to generalise results.

OVERVIEW OF THE FOUR PAPERS

In Paper Three, while only six problem solvers were interviewed, these in-depth interviews with a duration of between four and six hours each yielded rich data.

In the action research study described in Paper Four, the use of a single organization as a case site may be seen as a limitation. However, again, the nature of this research was in-depth. Feedback was limited to the perceived creativity of ideas generated in the ideation stage, as time constraints prevented the application of the final stage of planning for action.

37 KEY CONTRIBUTIONS OF THE FOUR PAPERS

The concentrated curiosity theory provides a theoretical contribution in the form of a novel theory of problem construction within the creative problem solving process.

In so doing, it addresses gaps in the literature regarding the information search and incorporates an integrated theory and novel approach to problem framing.

A methodological contribution is also offered by the normative framework which provides a detailed approach for practitioners to apply the theory in a real world context. To ensure that this normative framework is sufficiently robust, it incorporates insights from a variety of organisational contexts as well as inputs from problem solvers with direct experience of applying the framework.

A key contribution of the structured, rigorous normative framework that draws on evidence based guidelines, is the response to the call to integrate theory and practice (Paulus, Dickson, Korde, Cohen-Meitar, & Carmeli, 2016; Paulus & Kenworthy, 2018; Vernon, Hocking, & Tyler, 2016).

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APPENDIX A: GOOGLE FORM FOR COMPLETION BY PARTICIPANTS IN EXPERIMENT

Participant details

To assist me in planning for my PhD research into creative problem solving, I'd be grateful if you could entre your details below. Many thanks!

* Required

Email address*

Surname*

First name

Job level*

- ☐ Staff
- ☐ Associate specialist
- ☐ Specialist
- ☐ Senior specialist
- ☐ Manager

Job Type*

- ☐ Design and research
- ☐ Engineering
- ☐ Product

APPENDICES

For how long have you been employed by the company (Please note: This can include employment in other departments)*

- ☐ Up to 1 year
- ☐ Up to 2 years
- ☐ Up to 3 years
- ☐ Up to 4 years
- ☐ Up to 5 years
- ☐ Up to 6 years
- ☐ Up to 7 years
- ☐ Up to 8 years
- ☐ Up to 9 years
- ☐ Up to 10 years
- ☐ More than 10 years

In addition to being an employee, are you also a member ?

- ☐ Yes
- ☐ No

Are you interested in participating in my research on creative problem solving?

- ☐ Yes
- ☐ Maybe
- ☐ No

Many thanks for providing these details. I will be in touch if you are interested in participating in my research. If you do, I hope you will learn something valuable about creative problem solving and that it will help you to come up with some great ideas!

APPENDIX B: RESULTS OF ASSUMPTION TESTING BEFORE CONDUCTING MANOVA

Results of test for multivariate normality

	Tests of Normality					
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
BASELINE_CREATIVITY	.085	44	.200*	.979	44	.607
baseline_originality	.080	44	.200*	.969	44	.280
baseline_utility	.100	44	.200*	.972	44	.360

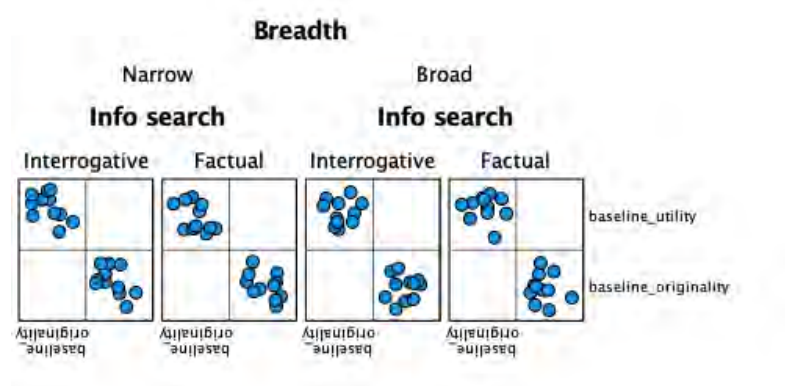
*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

	Residuals Statistics ^a				
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.41	1.57	1.50	.040	44
Std. Predicted Value	-2.151	1.792	.000	1.000	44
Standard Error of Predicted Value	.084	.217	.132	.030	44
Adjusted Predicted Value	1.36	1.61	1.50	.054	44
Residual	-.553	.570	.000	.504	44
Std. Residual	-1.071	1.104	.000	.976	44
Stud. Residual	-1.118	1.169	-.001	1.011	44
Deleted Residual	-.607	.639	-.001	.541	44
Stud. Deleted Residual	-1.121	1.174	.000	1.012	44
Mahal. Distance	.158	6.582	1.955	1.319	44
Cook's Distance	.009	.056	.025	.012	44
Centered Leverage Value	.004	.153	.045	.031	44

APPENDICES

Results of test for liner relationship between each pair of dependent variables for all combinations of groups of independent variables



Results of test for multicollinearity

Correlations

		baseline_ average_ originality	baseline_ average_ utility
baseline_average_originality	Pearson Correlation	1	.232
	Sig. (2-tailed)		.129
	N	44	44
baseline_average_utility	Pearson Correlation	.232	1
	Sig. (2-tailed)	.129	
	N	44	44

Results of test for homogeneity of variance

Box's Test of Equality of Covariance Matrices^a

Box's M	4.141
F	.418
df1	9
df2	18335.691
Sig.	.926

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

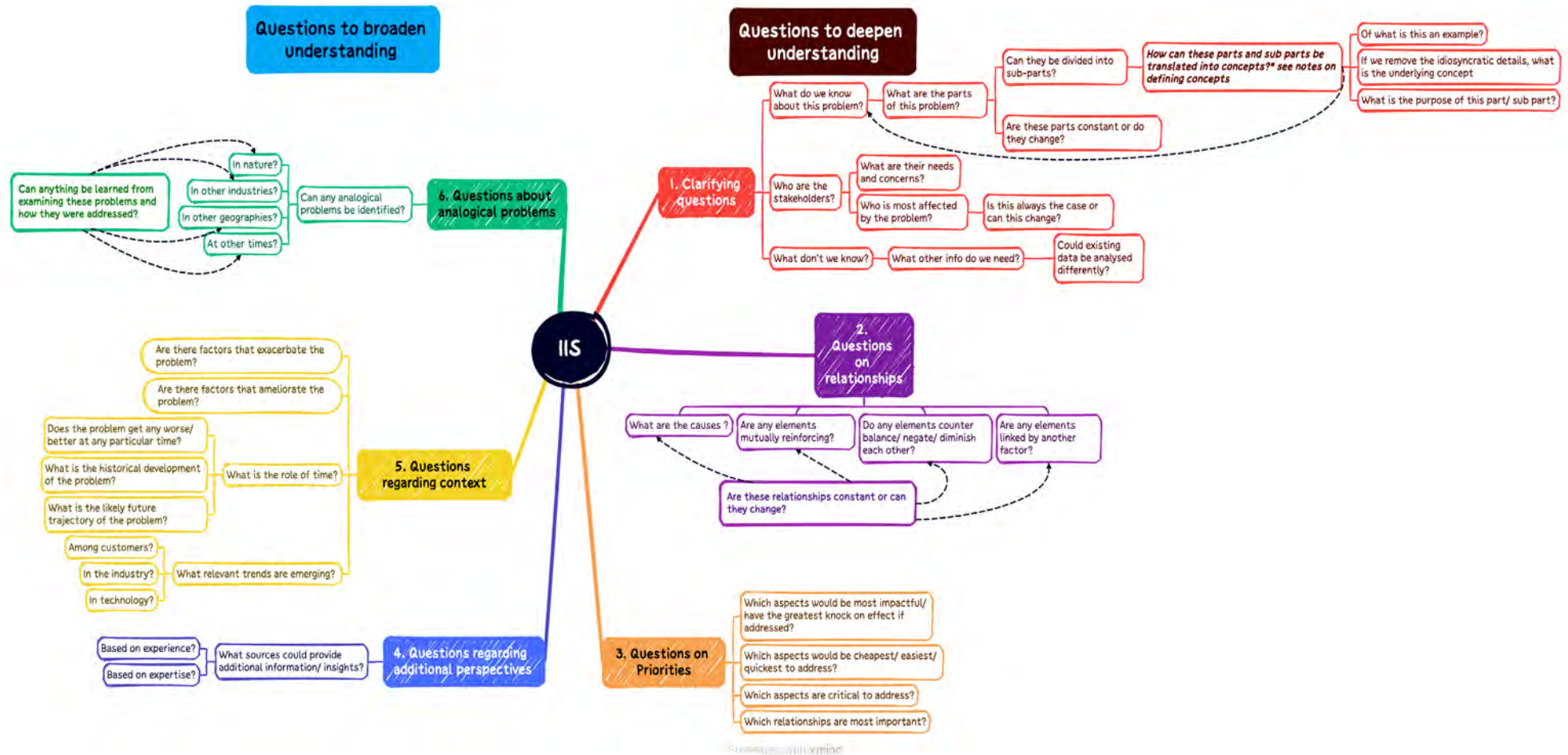
a. Design: Intercept + Breadth + Infosearch + Breadth * Infosearch

Within Subjects Design: time

APPENDIX C: VERSIONS OF INTERROGATIVE INFORMATION SEARCH FRAMEWORK

Interrogative information search: Draft 1

Overview



APPENDICES

Interrogative information search: Draft 1

Contents

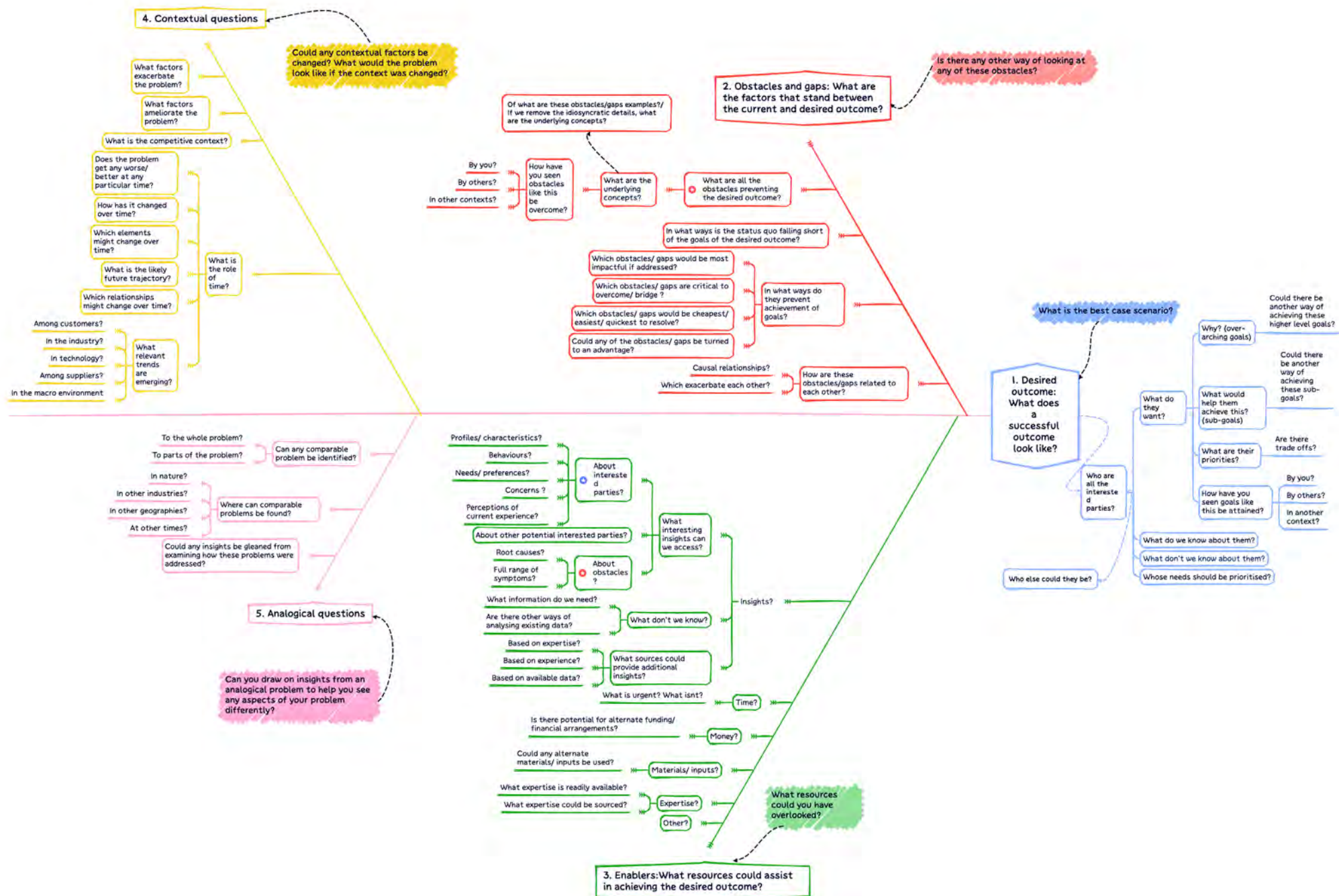
- 1. Clarifying questions
 - o What do we know about this problem?
 - What are the parts of this problem?
 - Can they be divided into sub-parts?
 - How can these parts and sub parts be translated into concepts?* see notes on defining concepts
 - Of what is this an example?
 - If we remove the idiosyncratic details, what is the underlying concept
 - What is the purpose of this part/ sub part?
 - Are these parts constant or do they change?
 - o Who are the stakeholders?
 - What are their needs and concerns?
 - Who is most affected by the problem?
 - Is this always the case or can this change?
 - o What don't we know?
 - What other info do we need?
 - Could existing data be analysed differently?
- 2. Questions on Priorities
 - o Which aspects would be most impactful/ have the greatest knock on effect if addressed?
 - o Which aspects would be cheapest/ easiest/ quickest to address?
 - o Which aspects are critical to address?
 - o Which relationships are most important?
- 3. Questions regarding context
 - o Are there factors that exacerbate the problem?
 - o Are there factors that ameliorate the problem?

APPENDICES

- o What is the role of time?
 - Does the problem get any worse/ better at any particular time?
 - What is the historical development of the problem?
 - What is the likely future trajectory of the problem?
 - o What relevant trends are emerging?
 - Among customers?
 - In the industry?
 - In technology?
- 4. Questions about analogical problems
 - o Can any analogical problems be identified?
 - In nature?
 - In other industries?
 - In other geographies?
 - At other times?
- 5. Questions on relationships
 - o What are the causes ?
 - o Are any elements mutually reinforcing?
 - o Do any elements counter balance/ negate/ diminish each other?
 - o Are any elements linked by another factor?
- 6. Questions regarding additional perspectives
 - o What sources could provide additional information/ insights?
 - Based on experience?
 - Based on expertise?
- Questions to deepen understanding
- Questions to broaden understanding
- Can anything be learned from examining these problems and how they were addressed?
- Are these relationships constant or can they change?

Interrogative information search: Draft 2

Overview



APPENDICES

Interrogative information search framework: Draft 2 **Contents**

- 1. Desired outcome: What does a successful outcome look like?
 - o Who are all the interested parties?
 - What do they want?
 - Why? (overarching goals)
 - Could there be another way of achieving these higher level goals?
 - What would help them achieve this? (sub-goals)
 - Could there be another way of achieving these sub-goals?
 - What are their priorities?
 - Are there trade-offs?
 - How have you seen goals like this be attained?
 - By you?
 - By others?
 - In another context?
 - What do we know about them?
 - What don't we know about them?
 - Whose needs should be prioritised?
 - Who else could they be?
 - o 2. Obstacles and gaps: What are the factors that stand between the current and desired outcome?
 - What are all the obstacles preventing the desired outcome?
 - What are the underlying concepts?
 - How have you seen obstacles like this be overcome?
 - By you?
 - By others?
 - In other contexts?

APPENDICES

- In what ways is the status quo falling short of the goals of the desired outcome?
- In what ways do they prevent achievement of goals?
 - Which obstacles/ gaps would be most impactful if addressed?
 - Which obstacles/ gaps are critical to overcome/ bridge ?
 - Which obstacles/ gaps would be cheapest/ easiest/ quickest to resolve?
 - Could any of the obstacles/ gaps be turned to an advantage?
- How are these obstacles/gaps related to each other?
 - Causal relationships?
 - Which exacerbate each other?
- o 3. Enablers:What resources could assist in achieving the desired outcome?
 - Other?
 - Expertise?
 - What expertise is readily available?
 - What expertise could be sourced?
 - Materials/ inputs?
 - Could any alternative materials/ inputs be used?
 - Money?
 - Is there potential for alternative funding/ financial arrangements?
 - Time?
 - What is urgent? What isn't?
 - Insights?
 - What interesting insights can we access?
 - About interested parties?
 - Profiles/ characteristics?
 - Behaviours?
 - Needs/ preferences?
 - Concerns ?

APPENDICES

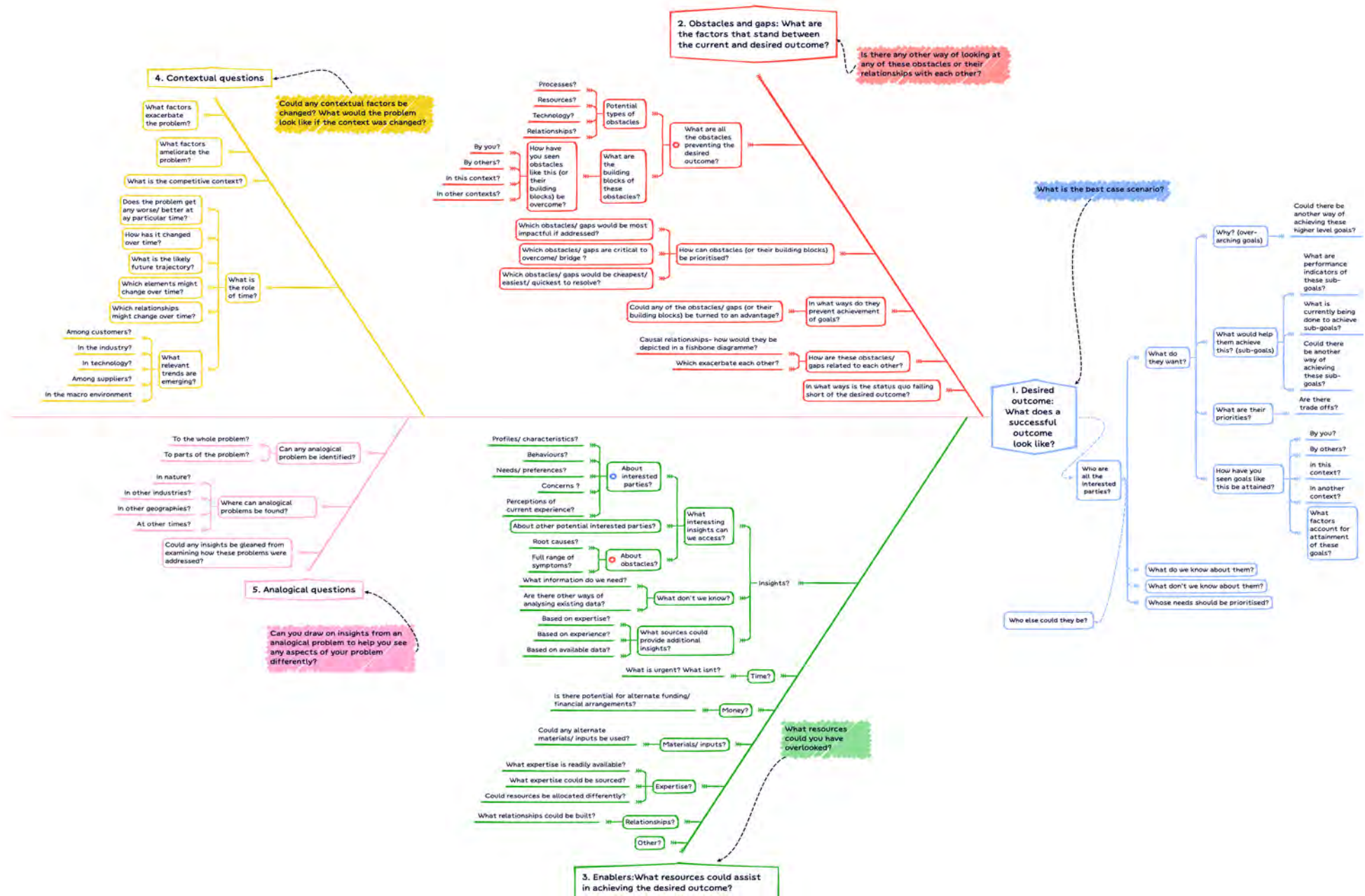
- Perceptions of current experience?
 - About other potential interested parties?
 - About obstacles?
 - Root causes?
 - Full range of symptoms?
 - What don't we know?
 - What information do we need?
 - Are there other ways of analysing existing data?
 - What sources could provide additional insights?
 - Based on expertise?
 - Based on experience?
 - Based on available data?
- o 4. Contextual questions
 - What factors exacerbate the problem?
 - What factors ameliorate the problem?
 - What is the competitive context?
 - What is the role of time?
 - Does the problem get any worse/ better at any particular time?
 - How has it changed over time?
 - Which elements might change over time?
 - What is the likely future trajectory?
 - Which relationships might change over time?

APPENDICES

- What relevant trends are emerging?
 - Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?
 - In the macro environment
- o 5. Analogical questions
 - Could any insights be gleaned from examining how these problems were addressed?
 - Where can comparable problems be found?
 - In nature?
 - In other industries?
 - In other geographies?
 - At other times?
 - Can any comparable problem be identified?
 - To the whole problem?
 - To parts of the problem?

Interrogative information search: Draft 3

Overview



APPENDICES

Interrogative information search framework: Draft 3

Contents

- 1. Desired outcome: What does a successful outcome look like?
 - o Who are all the interested parties?
 - What do they want?
 - Why? (overarching goals)
 - Could there be another way of achieving these higher level goals?
 - What would help them achieve this? (sub-goals)
 - What are performance indicators of these sub-goals?
 - What is currently being done to achieve these sub-goals?
 - Could there be another way of achieving these sub-goals?
 - What are their priorities?
 - Are there trade-offs?
 - How have you seen goals like this be attained?
 - By you?
 - By others?
 - In another context?
 - What factors account for attainment of these goals?
 - What do we know about them?
 - What don't we know about them?
 - Whose needs should be prioritised?
 - Who else could they be?
 - o 2. Obstacles and gaps: What are the factors that stand between the current and desired outcome?
 - What are all the obstacles preventing the desired outcome?
 - Potential types of obstacles
 - Processes?

APPENDICES

- Resources?
 - Technology?
 - Relationships?
 - What are the building blocks of these obstacles?
 - How have you seen obstacles like this (or their building blocks) be overcome?
 - By you?
 - By others?
 - In this context?
 - In other contexts?
 - How can obstacles (or their building blocks) be prioritised?
 - Which obstacles/ gaps would be most impactful if addressed?
 - Which obstacles/ gaps are critical to overcome/ bridge ?
 - Which obstacles/ gaps would be cheapest/ easiest/ quickest to resolve?
 - In what ways do they prevent achievement of goals?
 - Could any of the obstacles/ gaps (or their building blocks) be turned to an advantage?
 - How are these obstacles/gaps related to each other?
 - Causal relationships- how would they be depicted in a fishbone diagramme?
 - Which exacerbate each other?
 - In what ways is the status quo falling short of the desired outcome?
- o 3. Enablers:What resources could assist in achieving the desired outcome?
 - Other?
 - Relationships?
 - What relationships could be leveraged?
 - What relationships could be built?
 - Expertise?
 - What expertise is readily available?
 - What expertise could be sourced?

APPENDICES

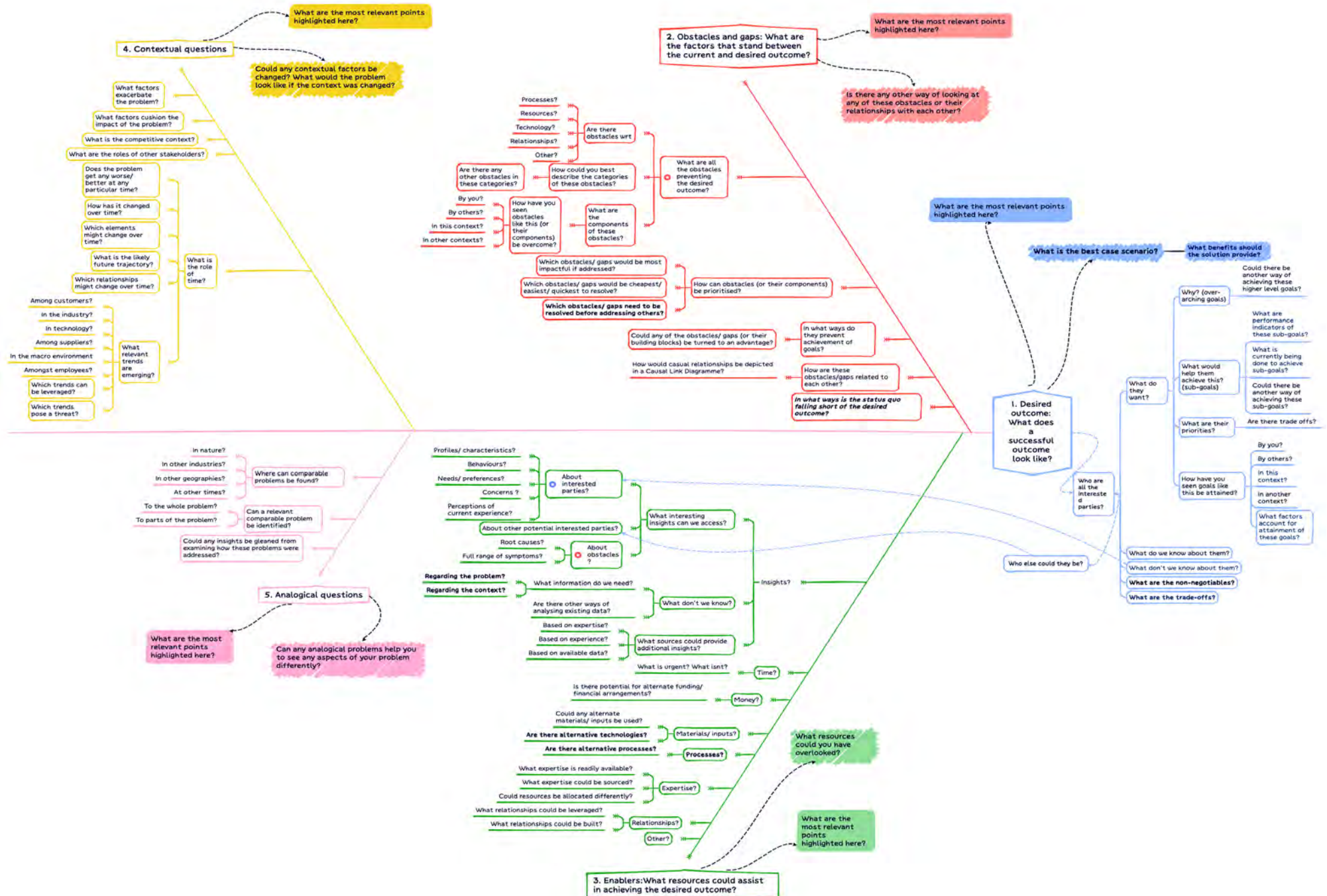
- Could resources be allocated differently?
 - Materials/ inputs?
 - Could any alternative materials/ inputs be used?
 - Money?
 - Is there potential for alternative funding/ financial arrangements?
 - Time?
 - What is urgent? What isn't?
 - Insights?
 - What interesting insights can we access?
 - About interested parties?
 - Profiles/ characteristics?
 - Behaviours?
 - Needs/ preferences?
 - Concerns ?
 - Perceptions of current experience?
 - About other potential interested parties?
 - About obstacles?
 - Root causes?
 - Full range of symptoms?
 - What don't we know?
 - What information do we need?
 - Are there other ways of analysing existing data?
 - What sources could provide additional insights?
 - Based on expertise?
 - Based on experience?
 - Based on available data?
- o 4. Contextual questions

APPENDICES

- What factors exacerbate the problem?
- What factors ameliorate the problem?
- What is the competitive context?
- What are the roles of other stakeholders?
- What is the role of time?
 - Does the problem get any worse/ better at any particular time?
 - How has it changed over time?
 - What is the likely future trajectory?
 - Which elements might change over time?
 - Which relationships might change over time?
 - What relevant trends are emerging?
 - Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?
 - In the macro environment
 - Amongst employees?
 - Which trends can be leveraged?
 - Which trends pose a threat?
- o 5. Analogical questions
 - Could any insights be gleaned from examining how these problems were addressed?
 - Can a relevant analogical problem be identified?
 - To the whole problem?
 - To parts of the problem?
 - Where can analogical problems be found?
 - In nature?
 - In other industries? In other geographies? At other times?

Interrogative information search: Draft 4

Overview



APPENDICES

Interrogative information search framework: Draft 4

Contents

- 1. Desired outcome: What does a successful outcome look like?
 - o Who are all the interested parties?
 - What do they want?
 - Why? (overarching goals)
 - Could there be another way of achieving these higher level goals?
 - What would help them achieve this? (sub-goals)
 - What are performance indicators of these sub-goals?
 - What is currently being done to achieve these sub-goals?
 - Could there be another way of achieving these sub-goals?
 - What are their priorities?
 - Are there trade-offs?
 - How have you seen goals like this be attained?
 - By you?
 - By others?
 - In another context?
 - What factors account for attainment of these goals?
 - What do we know about them?
 - What don't we know about them?
 - What are the non-negotiables?
 - What are the trade-offs?
 - Who else could they be?
 - o 2. Obstacles and gaps: What are the factors that stand between the current and desired outcome?
 - What are all the obstacles preventing the desired outcome?
 - Are there obstacles wrt

APPENDICES

- Processes?
 - Resources?
 - Technology?
 - Relationships?
 - Other?
 - How could you best describe the categories of these obstacles?
 - Are there any other obstacles in these categories?
 - What are the components of these obstacles?
 - How have you seen obstacles like this (or their components) be overcome?
 - By you?
 - By others?
 - In this context?
 - In other contexts?
 - How can obstacles (or their components) be prioritised?
 - Which obstacles/ gaps would be most impactful if addressed?
 - Which obstacles/ gaps would be cheapest/ easiest/ quickest to resolve?
 - Which obstacles/ gaps need to be resolved before addressing others?
 - In what ways do they prevent achievement of goals?
 - Could any of the obstacles/ gaps (or their building blocks) be turned to an advantage?
 - How are these obstacles/gaps related to each other?
 - How would casual relationships be depicted in a Causal Link Diagramme?
 - In what ways is the status quo falling short of the desired outcome?
- o 3. Enablers:What resources could assist in achieving the desired outcome?
- Other?
 - Relationships?
 - What relationships could be leveraged?
 - What relationships could be built?

APPENDICES

- Expertise?
 - What expertise is readily available?
 - What expertise could be sourced?
 - Could resources be allocated differently?
- Processes?
 - Are there alternative processes?
- Materials/ inputs?
 - Could any alternative materials/ inputs be used?
 - Are there alternative technologies?
- Money?
 - Is there potential for alternative funding/ financial arrangements?
- Time?
 - What is urgent? What isn't?
- Insights?
 - What interesting insights can we access?
 - About interested parties?
 - Profiles/ characteristics?
 - Behaviours?
 - Needs/ preferences?
 - Concerns ?
 - Perceptions of current experience?
 - About other potential interested parties?
 - About obstacles?
 - Root causes?
 - Full range of symptoms?
 - What don't we know?

APPENDICES

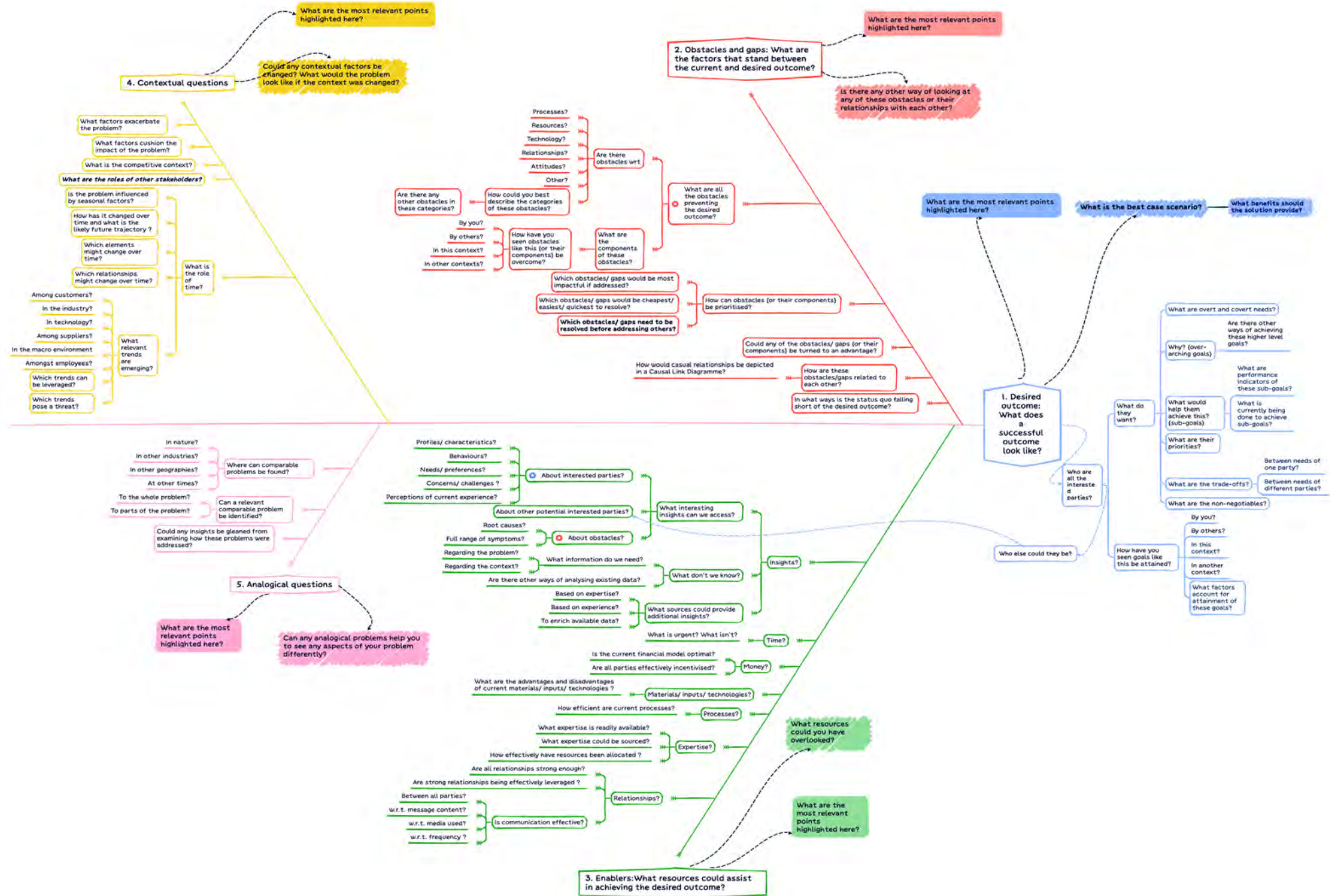
- What information do we need?
 - Regarding the problem?
 - Regarding the context?
 - Are there other ways of analysing existing data?
- What sources could provide additional insights?
 - Based on expertise?
 - Based on experience?
 - Based on available data?
- o 4. Contextual questions
 - What factors exacerbate the problem?
 - What factors cushion the impact of the problem?
 - What is the competitive context?
 - What are the roles of other stakeholders?
 - What is the role of time?
 - Does the problem get any worse/ better at any particular time?
 - How has it changed over time?
 - Which elements might change over time?
 - What is the likely future trajectory?
 - Which relationships might change over time?
 - What relevant trends are emerging?
 - Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?
 - In the macro environment
 - Amongst employees?
 - Which trends can be leveraged?

APPENDICES

- Which trends pose a threat?
- o 5. Analogical questions
 - Could any insights be gleaned from examining how these problems were addressed?
 - Can a relevant comparable problem be identified?
 - To the whole problem?
 - To parts of the problem?
 - Where can comparable problems be found?
 - In nature?
 - In other industries?
 - In other geographies?
 - At other times?

Interrogative information search: Draft 5

Overview



APPENDICES

Interrogative information search framework: Draft 5

Contents

- 1. Desired outcome: What does a successful outcome look like?
 - Who are all the interested parties?
 - What do they want?
 - What are overt and covert needs?
 - Why? (overarching goals)
 - Could there be another way of achieving these higher level goals?
 - What would help them achieve this? (sub-goals)
 - What are performance indicators of these sub-goals?
 - What is currently being done to achieve these sub-goals?
 - Could there be another way of achieving these sub-goals?
 - What are their priorities?
 - What are the trade-offs?
 - Between needs of one party?
 - Between needs of different parties?
 - What are the non-negotiables?
 - How have you seen goals like this be attained?
 - By you?
 - By others?
 - In this context?
 - In another context?
 - What factors account for attainment of these goals?
 - Who else could they be?
 - 2. Obstacles and gaps: What are the factors that stand between the current and desired outcome?
 - What are all the obstacles preventing the desired outcome?

APPENDICES

- Are there obstacles wrt
 - Processes?
 - Resources?
 - Technology?
 - Relationships?
 - Attitudes?
 - Other?
 - How could you best describe the categories of these obstacles?
 - Are there any other obstacles in these categories?
- What are the components of these obstacles?
 - How have you seen obstacles like this (or their components) be overcome?
 - By you?
 - By others?
 - In this context?
 - In other contexts?
- How can obstacles (or their components) be prioritised?
 - Which obstacles/ gaps would be most impactful if addressed?
 - Which obstacles/ gaps would be cheapest/ easiest/ quickest to resolve?
 - Which obstacles/ gaps need to be resolved before addressing others?
- Could any of the obstacles/ gaps (or their components) be turned to an advantage?
- How are these obstacles/gaps related to each other?
 - How would casual relationships be depicted in a Causal Link Diagramme?
- In what ways is the status quo falling short of the desired outcome?
- o 3. Enablers:What resources could assist in achieving the desired outcome?
 - Relationships?
 - Are all relationships strong enough?
 - Are strong relationships being effectively leveraged ?

APPENDICES

- Is communication effective?
 - Between all parties?
 - w.r.t. message content?
 - w.r.t. media used?
 - w.r.t. frequency ?
- Expertise?
 - What expertise is readily available?
 - What expertise could be sourced?
 - How effectively have resources been allocated ?
- Processes?
 - How efficient are current processes?
- Materials/ inputs/ technologies?
 - What are the advantages and disadvantages of current materials/ inputs/ technologies ?
- Money?
 - Is the current financial model optimal?
 - Are all parties effectively incentivised?
- Time?
 - What is urgent? What isn't?
- Insights?
 - What interesting insights can we access?
 - About interested parties?
 - Profiles/ characteristics?
 - Behaviours?
 - Needs/ preferences?
 - Concerns/ challenges ?
 - Perceptions of current experience?
 - About other potential interested parties?

APPENDICES

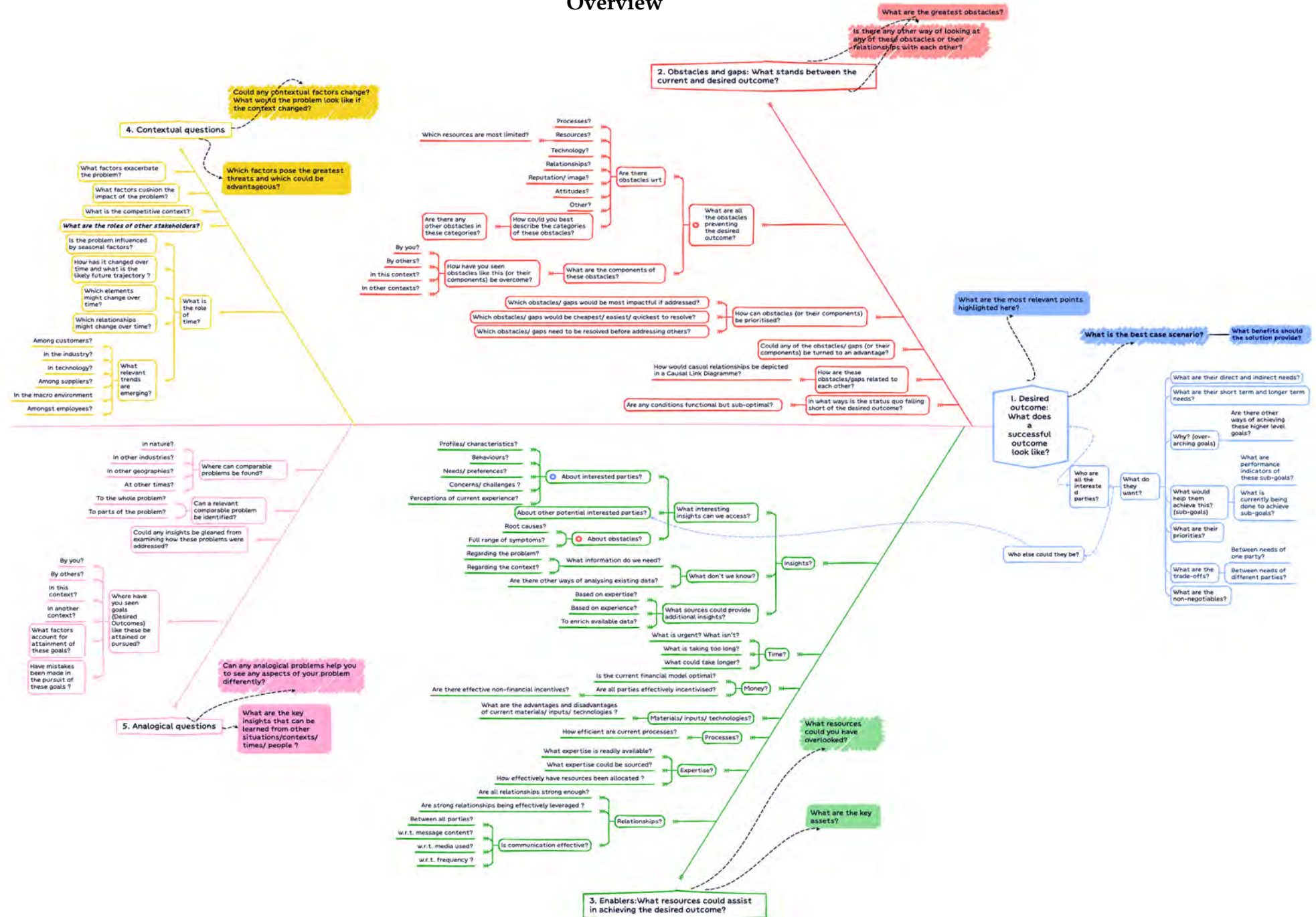
- About obstacles?
 - Root causes?
 - Full range of symptoms?
 - What don't we know?
 - What information do we need?
 - Regarding the problem?
 - Regarding the context?
 - Are there other ways of analysing existing data?
 - What sources could provide additional insights?
 - Based on expertise?
 - Based on experience?
 - To enrich available data?
- o 4. Contextual questions
 - What factors exacerbate the problem?
 - What factors cushion the impact of the problem?
 - What is the competitive context?
 - What are the roles of other stakeholders?
 - What is the role of time?
 - Is the problem influenced by seasonal factors?
 - How has it changed over time and what is the likely future trajectory ?
 - Which elements might change over time?
 - Which relationships might change over time?
 - What relevant trends are emerging?
 - Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?

APPENDICES

- In the macro environment
 - Amongst employees?
 - Which trends can be leveraged?
 - Which trends pose a threat?
- o 5. Analogical questions
 - Could any insights be gleaned from examining how these problems were addressed?
 - Can a relevant comparable problem be identified?
 - To the whole problem?
 - To parts of the problem?
 - Where can comparable problems be found?
 - In nature?
 - In other industries?
 - In other geographies?
 - At other times?

APPENDICES

Interrogative information search: Draft 6 Overview



APPENDICES

Interrogative information search framework: Draft 6

Contents

- 1. Desired outcome: What does a successful outcome look like?
 - o Who are all the interested parties?
 - What do they want?
 - What are their direct and indirect needs?
 - What are their short term and longer term needs?
 - Why? (overarching goals)
 - Could there be another way of achieving these higher level goals?
 - What would help them achieve this? (sub-goals)
 - What are performance indicators of these sub-goals?
 - What is currently being done to achieve these sub-goals?
 - What are their priorities?
 - What are the trade-offs?
 - Between needs of one party?
 - Between needs of different parties?
 - What are the non-negotiables?
 - Who else could they be?
 - o 2. Obstacles and gaps: What stands between the current and desired outcome?
 - What are all the obstacles preventing the desired outcome?
 - Are there obstacles wrt
 - Processes?
 - Resources?
 - Which resources are most limited?
 - Technology?
 - Relationships?

APPENDICES

- Reputation/ image?
 - Attitudes?
 - Other?
 - How could you best describe the categories of these obstacles?
 - Are there any other obstacles in these categories?
 - What are the components of these obstacles?
 - How have you seen obstacles like this (or their components) be overcome?
 - By you?
 - By others?
 - In this context?
 - In other contexts?
 - How can obstacles (or their components) be prioritised?
 - Which obstacles/ gaps would be most impactful if addressed?
 - Which obstacles/ gaps would be cheapest/ easiest/ quickest to resolve?
 - Which obstacles/ gaps need to be resolved before addressing others?
 - Could any of the obstacles/ gaps (or their components) be turned to an advantage?
 - How are these obstacles/gaps related to each other?
 - How would casual relationships be depicted in a Causal Link Diagramme?
 - In what ways is the status quo falling short of the desired outcome?
 - Are any conditions functional but sub-optimal?
- o 3. Enablers: What resources could assist in achieving the desired outcome?
 - Relationships?
 - Are all relationships strong enough?
 - Are strong relationships being effectively leveraged ?
 - Is communication effective?
 - Between all parties?
 - w.r.t. message content?

APPENDICES

- w.r.t. media used?
 - w.r.t. frequency ?
- Expertise?
 - What expertise is readily available?
 - What expertise could be sourced?
 - How effectively have resources been allocated ?
- Processes?
 - How efficient are current processes?
- Materials/ inputs/ technologies?
 - What are the advantages and disadvantages of current materials/ inputs/ technologies ?
- Money?
 - Is the current financial model optimal?
 - Are all parties effectively incentivised?
 - Are there effective non-financial incentives?
- Time?
 - What is urgent? What isn't?
 - What is taking too long?
 - What could take longer?
- Insights?
 - What interesting insights can we access?
 - About interested parties?
 - Profiles/ characteristics?
 - Behaviours?
 - Needs/ preferences?
 - Concerns/ challenges ?
 - Perceptions of current experience?

APPENDICES

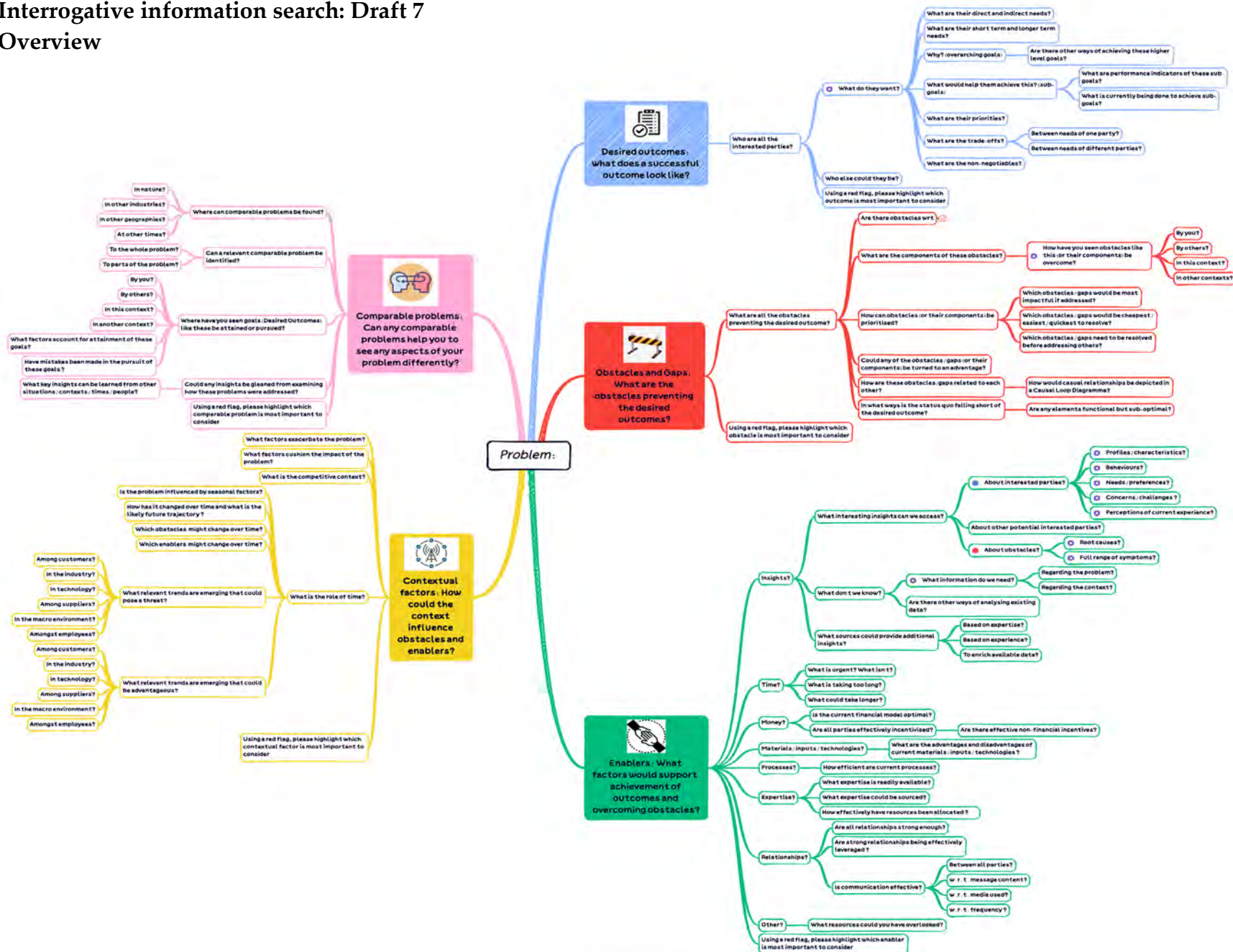
- About other potential interested parties?
 - About obstacles?
 - Root causes?
 - Full range of symptoms?
 - What don't we know?
 - What information do we need?
 - Regarding the problem?
 - Regarding the context?
 - Are there other ways of analysing existing data?
 - What sources could provide additional insights?
 - Based on expertise?
 - Based on experience?
 - To enrich available data?
- o 4. Contextual questions
 - What factors exacerbate the problem?
 - What factors cushion the impact of the problem?
 - What is the competitive context?
 - What is the role of time?
 - Is the problem influenced by seasonal factors?
 - How has it changed over time and what is the likely future trajectory ?
 - Which obstacles might change over time?
 - Which enablers might change over time?
 - Which relationships might change over time?
 - What relevant trends are emerging that could pose a threat?
 - Among customers?
 - In the industry?
 - In technology?

APPENDICES

- Among suppliers?
 - In the macro environment
 - Amongst employees?
- What relevant trends are emerging that could be advantageous?
 - Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?
 - In the macro environment
 - Amongst employees?
- o 5. Analogical questions
 - Where have you seen goals (Desired Outcomes) like these be attained or pursued?
 - By you?
 - By others?
 - In this context?
 - In another context?
 - What factors account for attainment of these goals?
 - Have mistakes been made in the pursuit of these goals ?
 - Could any insights be gleaned from examining how these problems were addressed?
 - Can a relevant comparable problem be identified?
 - To the whole problem?
 - To parts of the problem?
 - Where can comparable problems be found?
 - In nature?
 - In other industries?
 - In other geographies?
 - At other times?

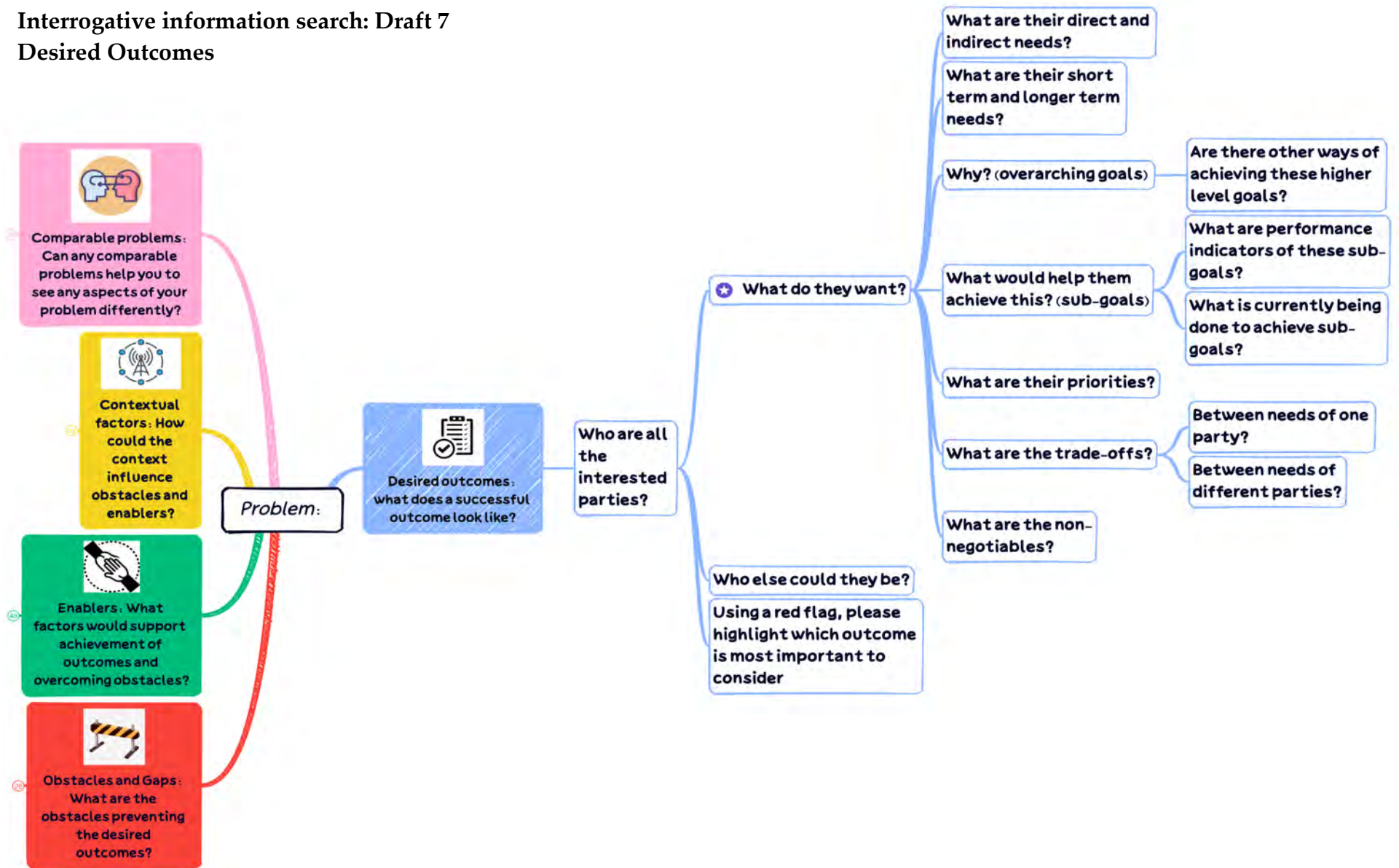
APPENDICES

Interrogative information search: Draft 7 Overview

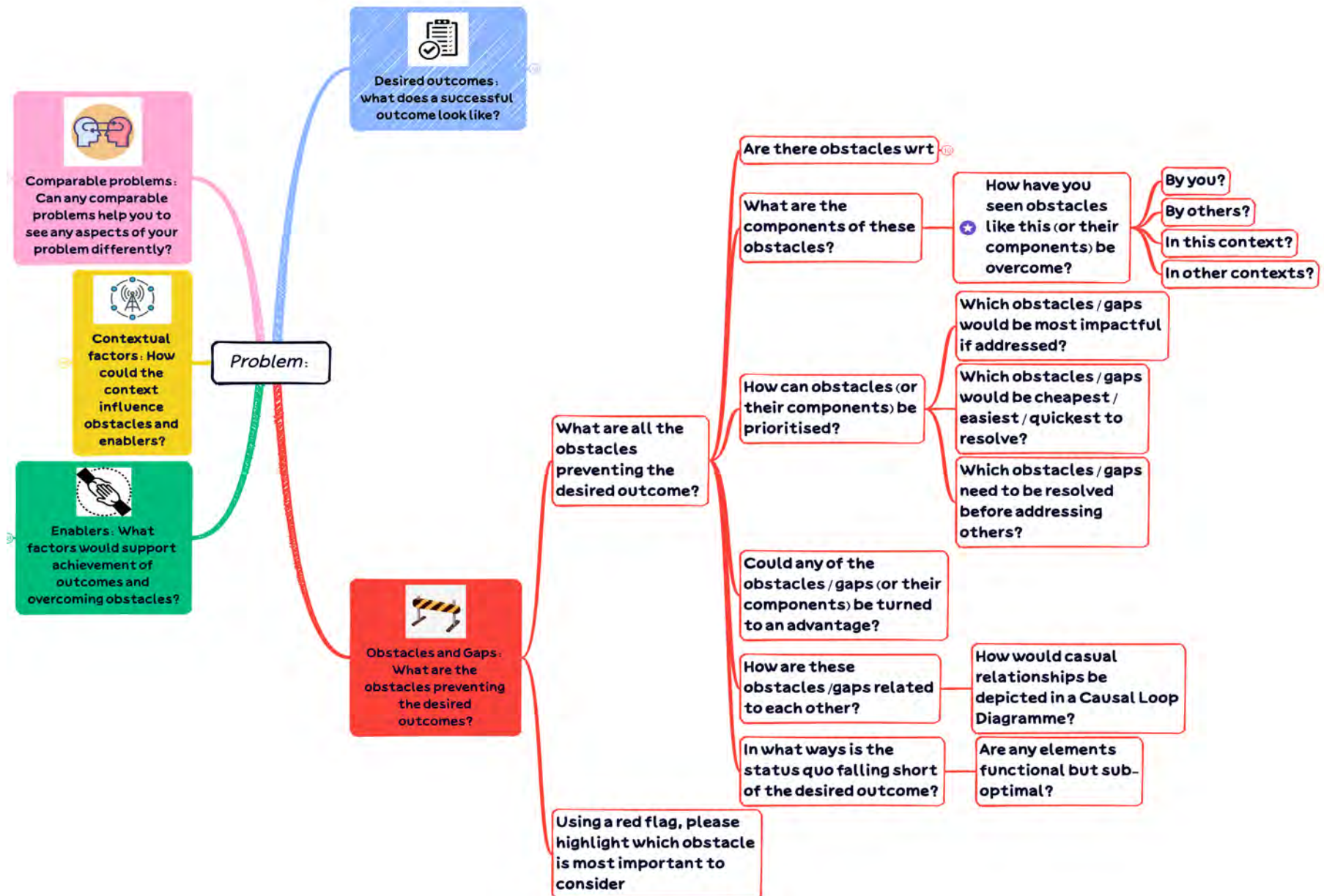


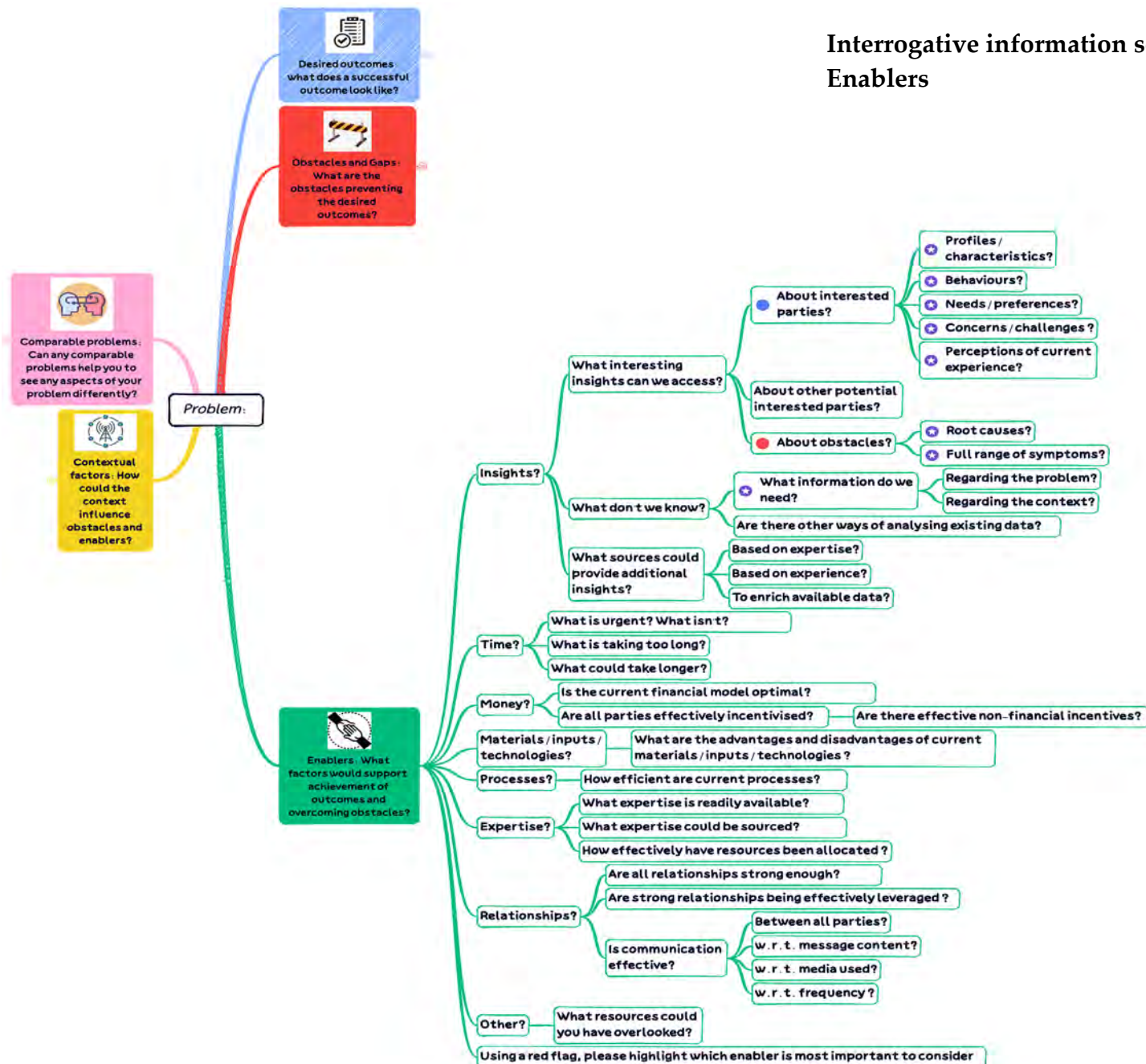
APPENDICES

Interrogative information search: Draft 7 Desired Outcomes



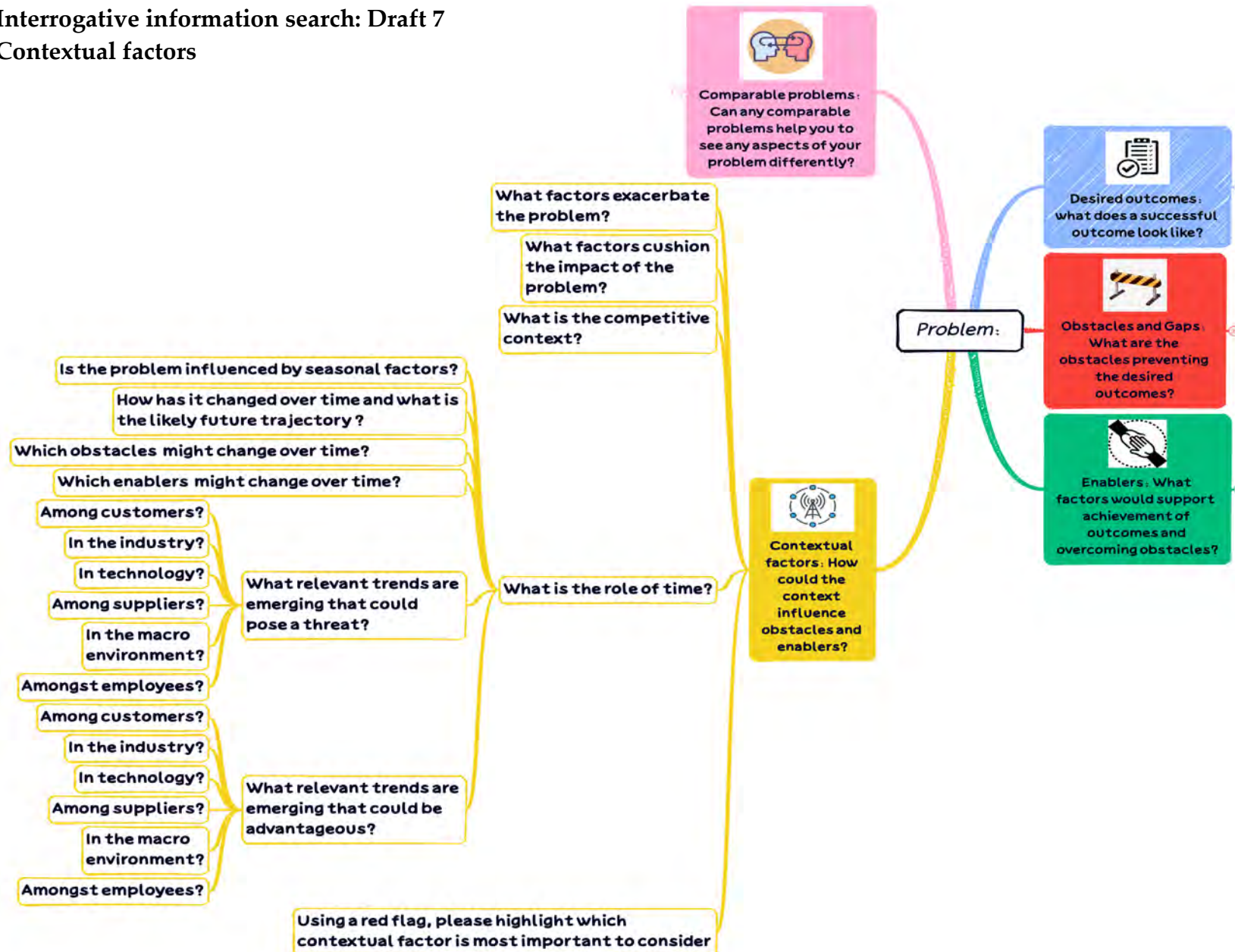
Interrogative information search: Draft 7 Obstacles



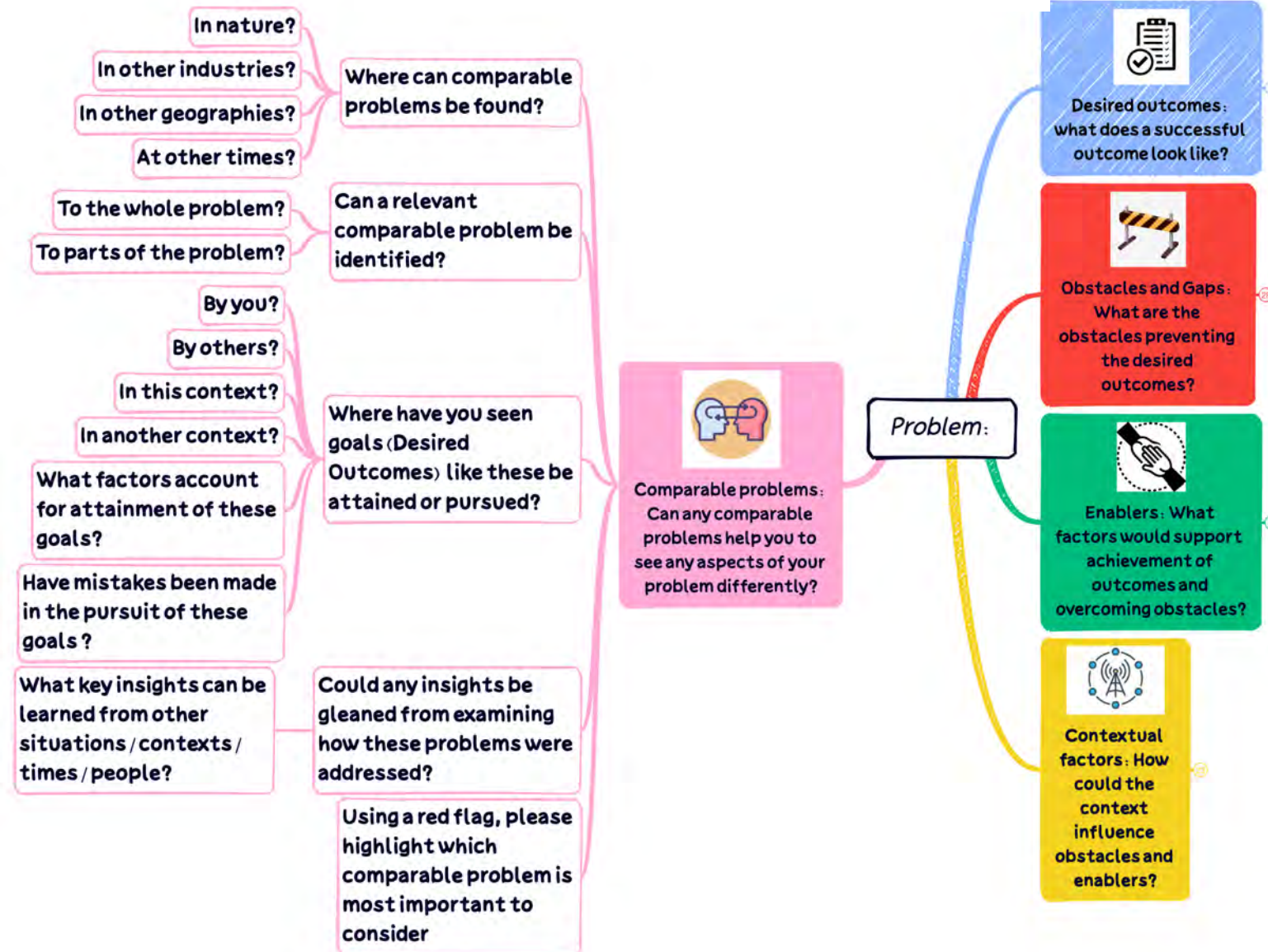


APPENDICES

Interrogative information search: Draft 7 Contextual factors



Interrogative information search: Draft 7
Comparable problems/ Analogies



APPENDICES

Interrogative information search framework: Draft 7

Contents

1. Desired outcomes: what does a successful outcome look like?
 - Who are all the interested parties?
 - What do they want?
 - What are their direct and indirect needs?
 - What are their short term and longer term needs?
 - Why? (overarching goals)
 - Are there other ways of achieving these higher level goals?
 - What would help them achieve this? (sub-goals)
 - What are performance indicators of these sub-goals?
 - What is currently being done to achieve sub-goals?
 - What are their priorities?
 - What are the trade-offs?
 - Between needs of one party?
 - Between needs of different parties?
 - What are the non-negotiables?
 - Who else could they be?
 - Using a red flag, please highlight which outcome is most important to consider
2. Obstacles and Gaps: What are the obstacles preventing the desired outcomes?
 - What are all the obstacles preventing the desired outcome?
 - Are there obstacles wrt
 - Processes?
 - Resources?
 - Which resources are most limited?
 - Technology?

APPENDICES

- Relationships?
 - Reputation/ image?
 - Attitudes?
 - Other?
 - How could you best describe the categories of these obstacles?
 - Are there any other obstacles in these categories?
 - What are the components of these obstacles?
 - How have you seen obstacles like this (or their components) be overcome?
 - By you?
 - By others?
 - In this context?
 - In other contexts?
 - How can obstacles (or their components) be prioritised?
 - Which obstacles/ gaps would be most impactful if addressed?
 - Which obstacles/ gaps would be cheapest/ easiest/ quickest to resolve?
 - Which obstacles/ gaps need to be resolved before addressing others?
 - Could any of the obstacles/ gaps (or their components) be turned to an advantage?
 - How are these obstacles/gaps related to each other?
 - How would casual relationships be depicted in a Causal Loop Diagramme?
 - In what ways is the status quo falling short of the desired outcome?
 - Are any elements functional but sub-optimal?
 - Using a red flag, please highlight which obstacle is most important to consider
3. Enablers: What factors would support achievement of outcomes and overcoming obstacles?
- Insights?
 - What interesting insights can we access?
 - About interested parties?
 - Profiles/ characteristics?

APPENDICES

- Behaviours?
 - Needs/ preferences?
 - Concerns/ challenges ?
 - Perceptions of current experience?
- About other potential interested parties?
- About obstacles?
 - Root causes?
 - Full range of symptoms?
- What don't we know?
 - What information do we need?
 - Regarding the problem?
 - Regarding the context?
 - Are there other ways of analysing existing data?
- What sources could provide additional insights?
 - Based on expertise?
 - Based on experience?
 - To enrich available data?
- Time?
 - What is urgent? What isn't?
 - What is taking too long?
 - What could take longer?
- Money?
 - Is the current financial model optimal?
 - Are all parties effectively incentivised?
 - Are there effective non-financial incentives?
- Materials/ inputs/ technologies?
 - What are the advantages and disadvantages of current materials/ inputs/ technologies ?

APPENDICES

- Processes?
 - How efficient are current processes?
 - Expertise?
 - What expertise is readily available?
 - What expertise could be sourced?
 - How effectively have resources been allocated ?
 - Relationships?
 - Are all relationships strong enough?
 - Are strong relationships being effectively leveraged ?
 - Is communication effective?
 - Between all parties?
 - w.r.t. message content?
 - w.r.t. media used?
 - w.r.t. frequency ?
 - Other?
 - What resources could you have overlooked?
 - Using a red flag, please highlight which enabler is most important to consider
4. Contextual factors: How could the context influence obstacles and enablers?
- What factors exacerbate the problem?
 - What factors cushion the impact of the problem?
 - What is the competitive context?
 - What is the role of time?
 - Is the problem influenced by seasonal factors?
 - How has it changed over time and what is the likely future trajectory ?
 - Which obstacles might change over time?
 - Which enablers might change over time?
 - What relevant trends are emerging that could pose a threat?

APPENDICES

- Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?
 - In the macro environment?
 - Amongst employees?
 - What relevant trends are emerging that could be advantageous?
 - Among customers?
 - In the industry?
 - In technology?
 - Among suppliers?
 - In the macro environment?
 - Amongst employees?
 - Using a red flag, please highlight which contextual factor is most important to consider
5. Comparable problems: Can any comparable problems help you to see any aspects of your problem differently?
- Where can comparable problems be found?
 - In nature?
 - In other industries?
 - In other geographies?
 - At other times?
 - Can a relevant comparable problem be identified?
 - To the whole problem?
 - To parts of the problem?
 - Where have you seen goals (Desired Outcomes) like these be attained or pursued?
 - By you?
 - By others?
 - In this context?

APPENDICES

- In another context?
- What factors account for attainment of these goals?
- Have mistakes been made in the pursuit of these goals ?
- Could any insights be gleaned from examining how these problems were addressed?
 - What key insights can be learned from other situations/ contexts/ times/ people?
- Using a red flag, please highlight which comparable problem is most important to consider

APPENDIX D: DISCUSSION GUIDE FOR INTERVIEWS ON NORMATIVE FRAMEWORK

I'd like you to please think of a problem for which you have had to find a creative solution. This problem would have been complex, not well or easily defined and didn't have one correct answer.

I'm going to take you through a series of questions which one could ask about such a problem which would where you had to conduct an extensive search for information to enable you to solve the problem. The aims of these questions are twofold, namely, to help you:

- **Extend and deepen your understanding of the problem in your own mind, and**
- **Start to see your problem in a new way, or see new angles or perspectives on your problem.**

Going through the interrogative information search:

As we go through these questions I'd like your feedback on

1. Whether these questions are relevant for your problem
2. Any questions you would
 - a. Modify?,
 - b. Exclude?, or
 - c. Add?

Given the two objectives of this interrogative information search

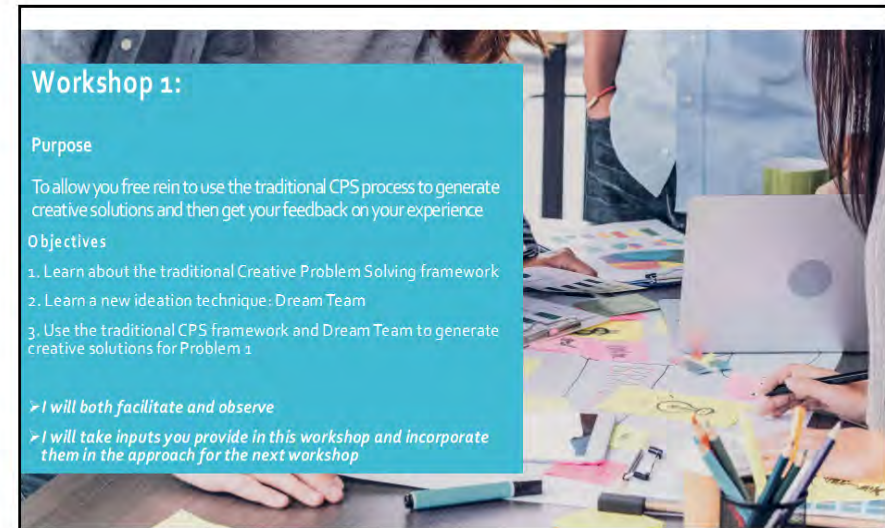
After going through the interrogative information search:

3. To what extent has answering these questions helped you to see your problem differently?
4. Which (if any) questions or aspects of the framework helped you to think of your problem differently or find a new angle or perspective on your problem?
5. Did any new questions emerge for you as a result of your information search?

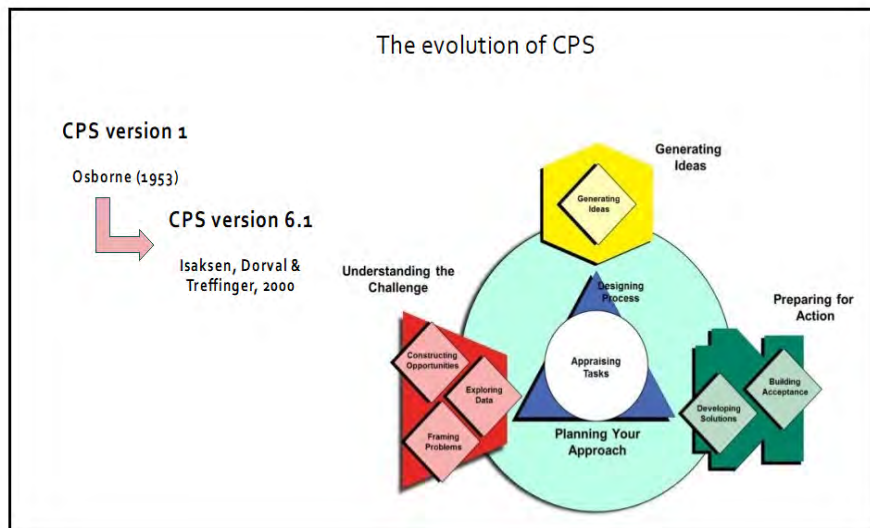
APPENDIX E: SLIDES OF INSTRUCTIONS TO ACTION RESEARCH PARTICIPANTS



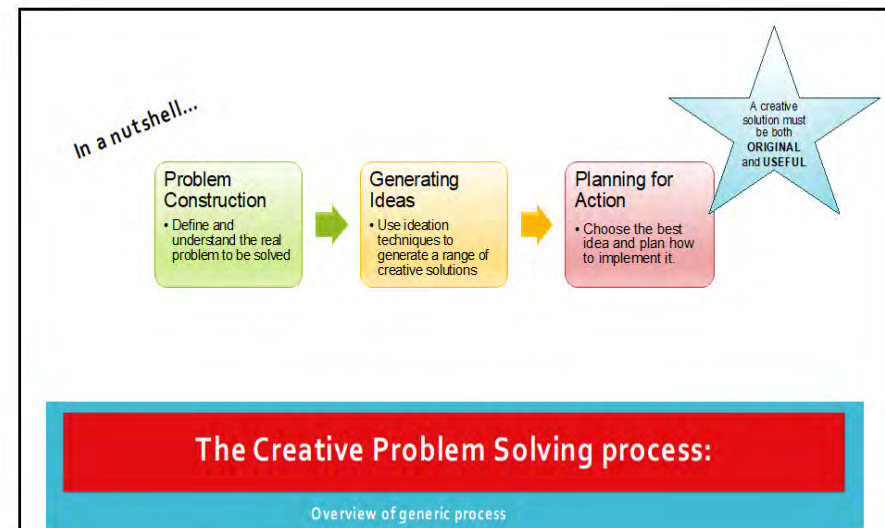
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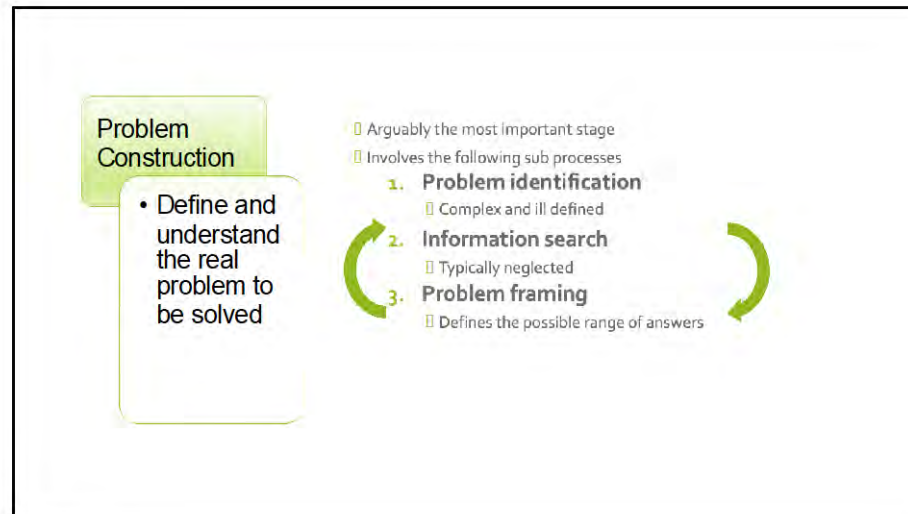


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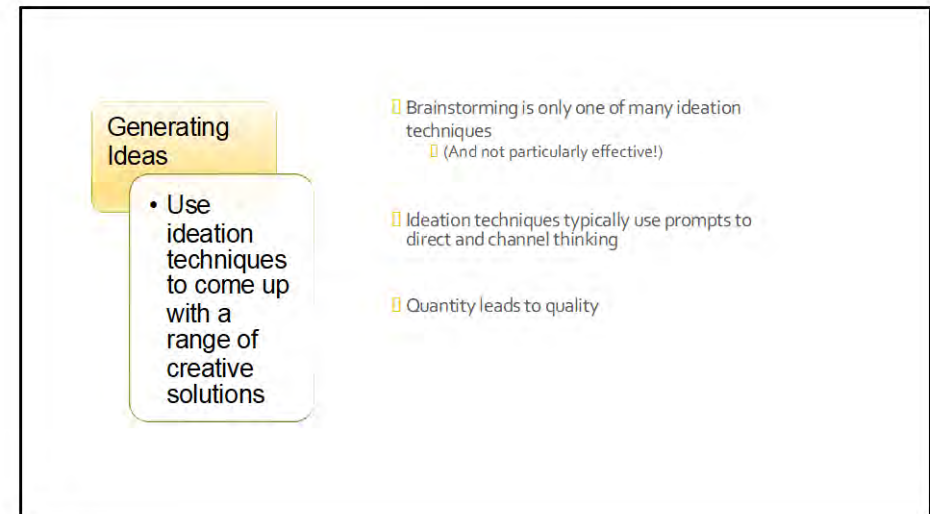


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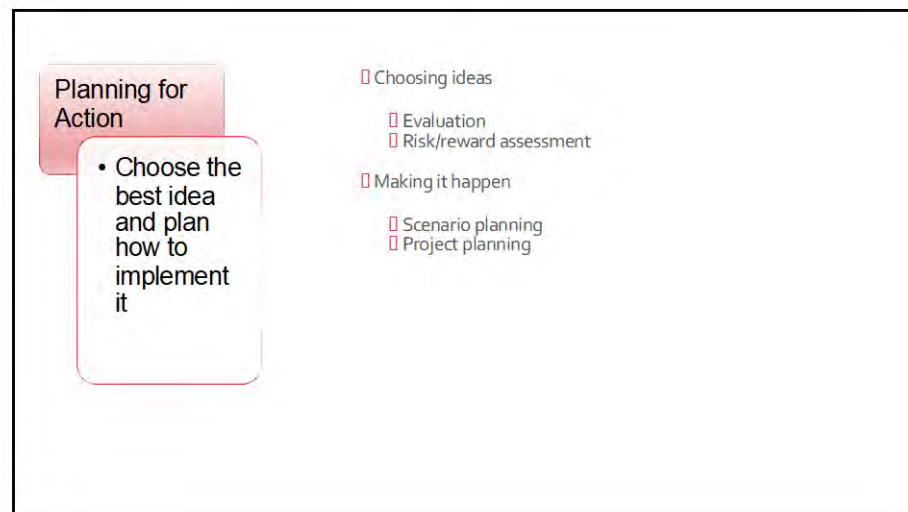
APPENDICES



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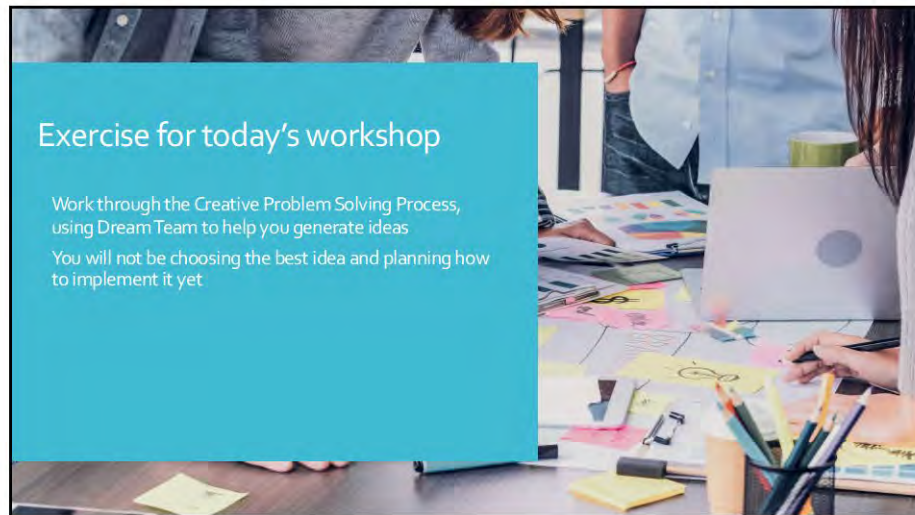
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Generating ideas using the Dream Team technique	
Diminish or Downscale Are there parts of the problem you can diminish or downscale?	Tailor Are there parts of the problem you can tailor to address specific needs/ purposes/ people?
Resourcing Could you consider alternative resources for managing the problem, such as by outsourcing or partnering with others?	Emulate Are there examples of how this challenge or similar challenges have been addressed by others that you can learn from and emulate?
Extract Are there aspects of the problem that can be extracted or eliminated?	Automate Is there a way you can harness or make better use of technology?
Add Is there a new element you could add or introduce to combine with existing elements?	Make Magic What can be done to add a spark of something special?
Magnify Could you magnify or exaggerate any aspect(s)?	

8

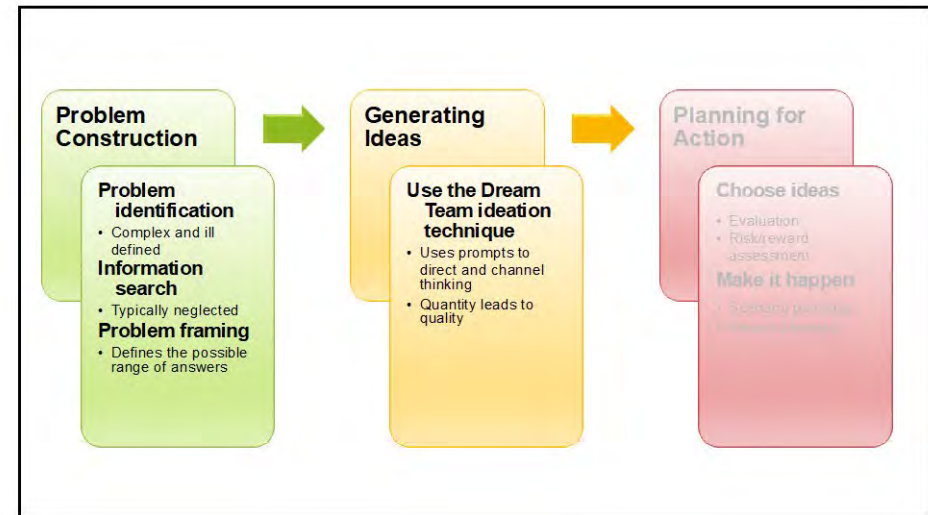


Exercise for today's workshop

Work through the Creative Problem Solving Process, using Dream Team to help you generate ideas

You will not be choosing the best idea and planning how to implement it yet

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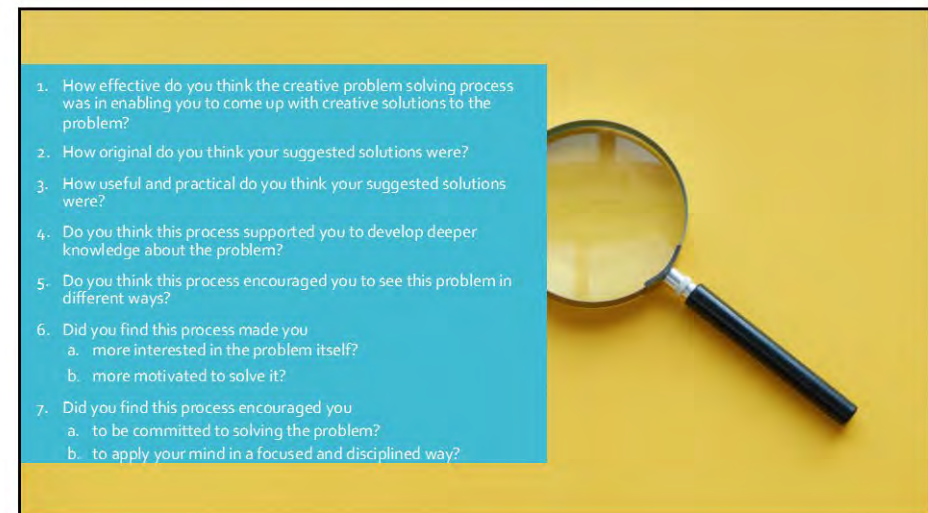


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1st Focus group to discuss your experience

11



- How effective do you think the creative problem solving process was in enabling you to come up with creative solutions to the problem?
- How original do you think your suggested solutions were?
- How useful and practical do you think your suggested solutions were?
- Do you think this process supported you to develop deeper knowledge about the problem?
- Do you think this process encouraged you to see this problem in different ways?
- Did you find this process made you
 - more interested in the problem itself?
 - more motivated to solve it?
- Did you find this process encouraged you
 - to be committed to solving the problem?
 - to apply your mind in a focused and disciplined way?

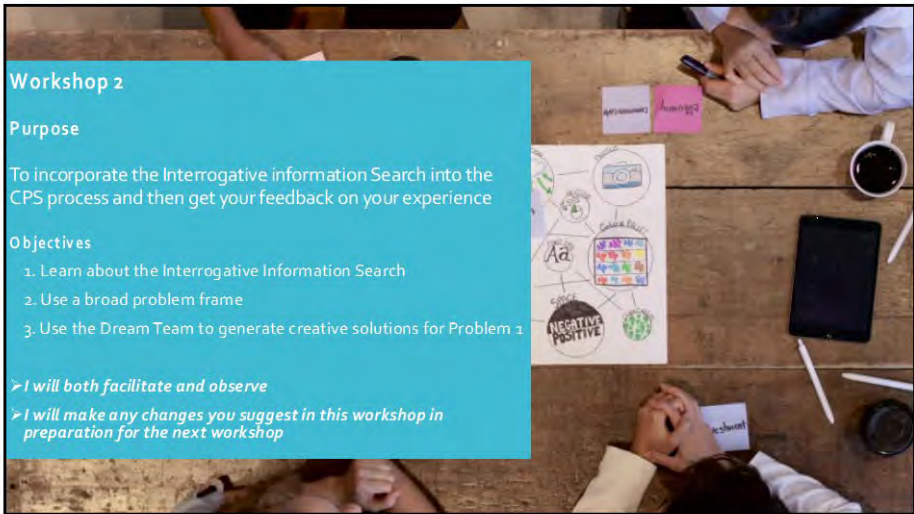
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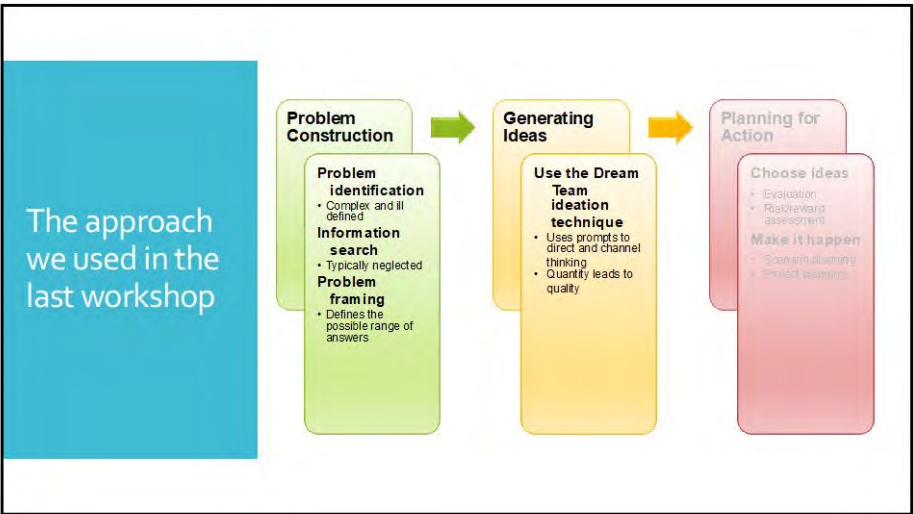
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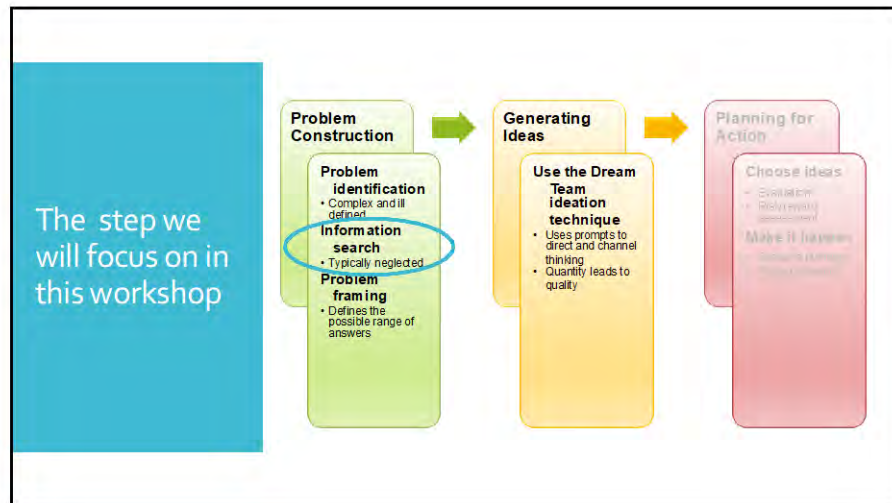
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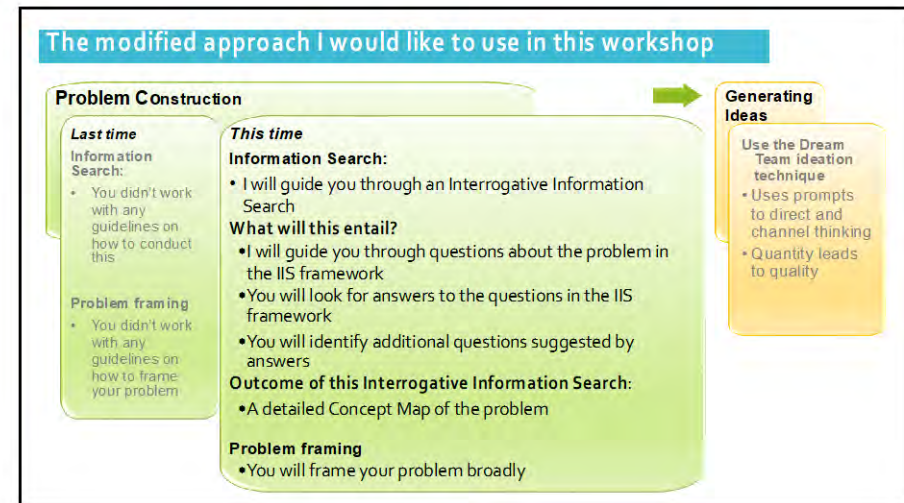
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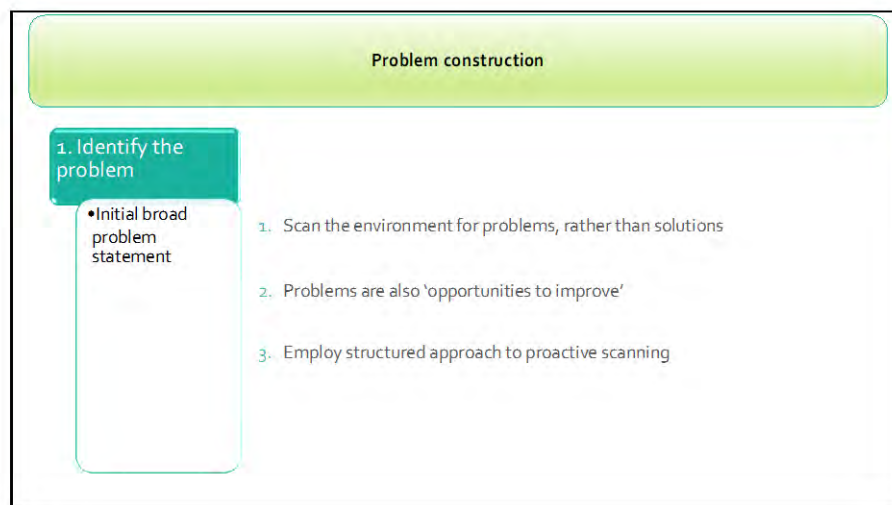
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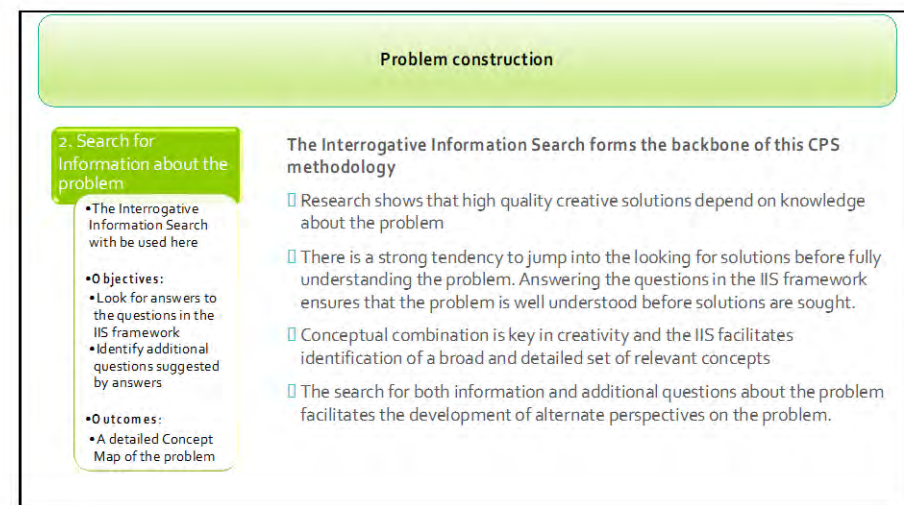
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Problem construction

Guidelines for using the Interrogative Information Search

1. The IIS Framework poses questions about the problem.

2. The aim of the IIS is to facilitate both a deeper and broader understanding of the problem.

3. Responses to certain questions may require further research as not all questions may be answered immediately.

4. Not all questions deserve equal attention for your problem. While some questions do need further consideration, even if at first they do not appear overly relevant, focus on answering the questions that you find most interesting and provocative.

5. Not all questions may be relevant, but if at first a question appears not to be relevant to the problem, attempt to probe whether this is indeed the case before moving on to the next question.

6. Questions should be addressed in the sequence prescribed by the framework, but If pondering latter questions evokes thoughts on questions already considered, go back to these questions and provide the relevant responses. Then resume reflecting on questions as per the sequence.

7. Responses to questions should be documented in the concept map as sub-topics. Answers should be highlighted to visually distinguish them from questions.

8. When particularly useful insights are noted, they should be flagged by noting this on the concept map.

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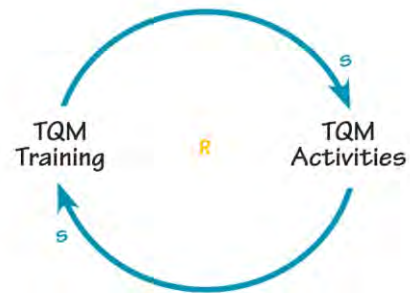
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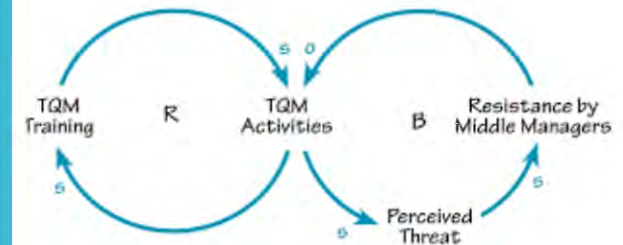
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Examples of
Causal Loop
Diagrams:
Simple 2



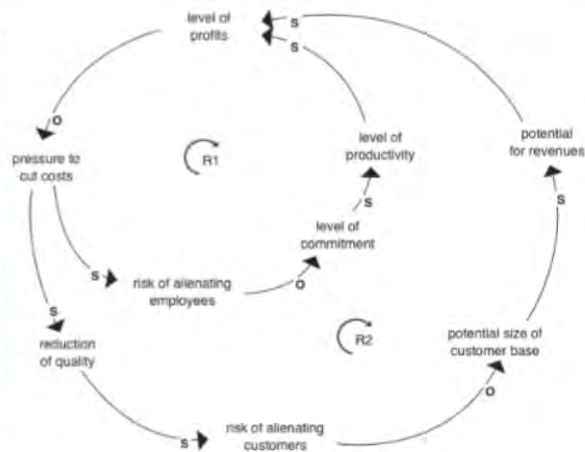
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Examples of
Causal Loop
Diagrams:
More complex



26

Examples of
Causal Loop
Diagrams:
Even more complex



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Before our
next
workshop...

- Look for answers to questions which you couldn't answer
- Identify any new questions that emerge as a result

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Problem construction

3. Frame the problem

- Use the Concept Map of the problem
- Frame the problem broadly

1. Looking at the Concept Map of the problem as it currently stands, how would you frame the problem in broad terms

2. Remember that the problem frame is the frame you put around the problem and will encompass the elements you want to address



The concept map shows a central node 'Vacuum cleaner' connected to various related concepts. On the left, there are nodes for 'Interrogative Information Search', 'Comparison of the building', 'Interrogative Information Search', 'Interrogative Information Search', 'Interrogative Information Search', 'Interrogative Information Search', 'Interrogative Information Search', 'Interrogative Information Search', 'Interrogative Information Search', 'Interrogative Information Search'. On the right, there are nodes for 'Function', 'Power source', 'Suction', 'Blow', 'Electronics', 'City', 'Environment', 'Indoor', 'Outdoor', 'Vacuum cleaner', 'Interrogative Information Search'.

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Generating ideas using the Dream Team technique

1. Generate ideas to address the broad problem frame

- Use the DREAM TEAM ideation tool to generate creative solutions to this broad problem frames

Diminish or Downscale Are there parts of the problem you can diminish or downscale?	Tailor Are there parts of the problem you can tailor to address specific needs/ purposes/ people?
Resourcing Could you consider alternative resources for managing the problem, such as by outsourcing or partnering with others?	Emulate Are there examples of how this challenge or similar challenges have been addressed by others that you can learn from and emulate?
Extract Are there aspects of the problem that can be extracted or eliminated?	Automate Is there a way you can harness or make better use of technology?
Add Is there a new element you could add or introduce to combine with existing elements?	Make Magic What can be done to add a spark of something special ?
Magnify Could you magnify or exaggerate any aspect(s) ?	

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2nd Focus group to discuss your experience

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1. Reflecting on the Interrogative Information Search, how useful were the questions in expanding your understanding of the problem?

a. Did this process help you to get a deeper understanding of the problem?

b. Did this process help you to get a broader understanding of the problem?

c. Did the questions make you more curious about the problem?

d. Did the questions follow on from each other logically?

2. Compared to the last workshop, how effective do you think this approach was in enabling you to come up with creative solutions to the problem?

3. If you were to compare the solutions you generated in this workshop to those you generated in the last workshop, do you think they were less, more or just as original?

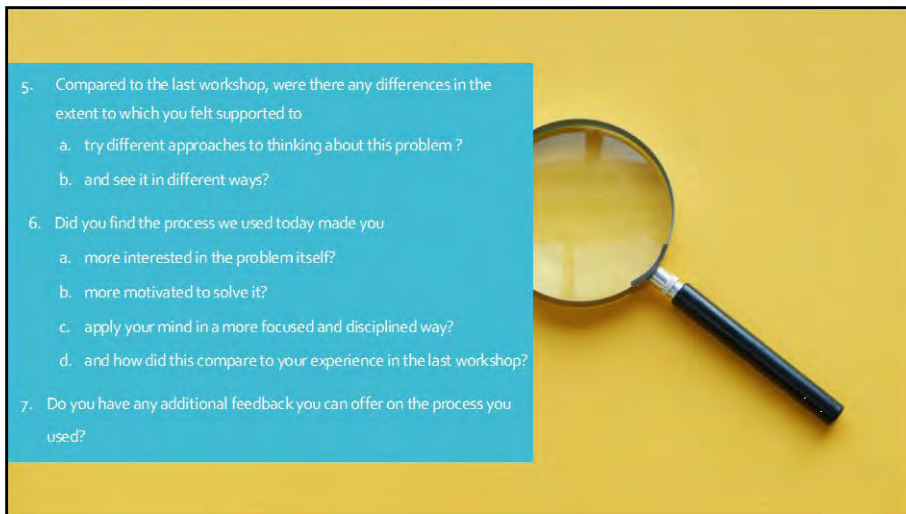
4. If you were to compare the solutions you generated in this workshop to those you generated in the last workshop, do you think they were less, more or just as useful and practical?



A magnifying glass with a black handle and a silver frame, resting on a yellow surface.

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APPENDICES



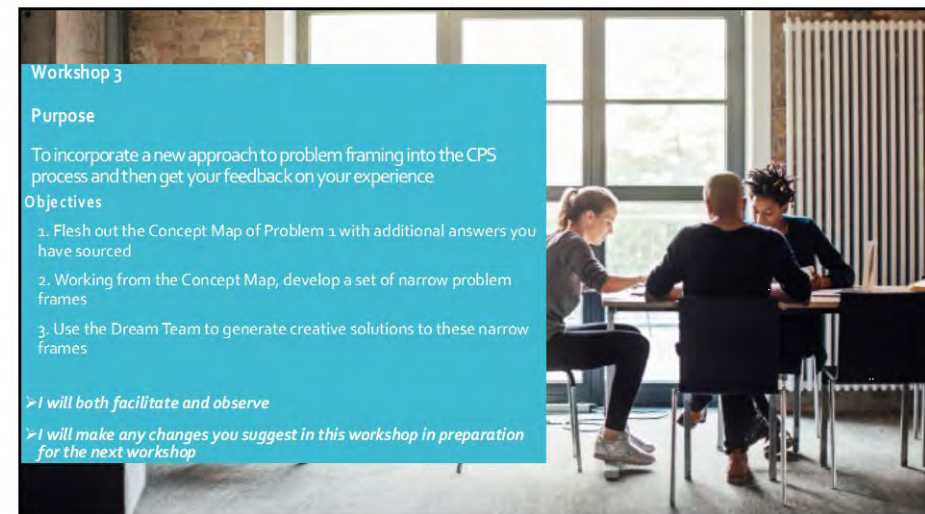
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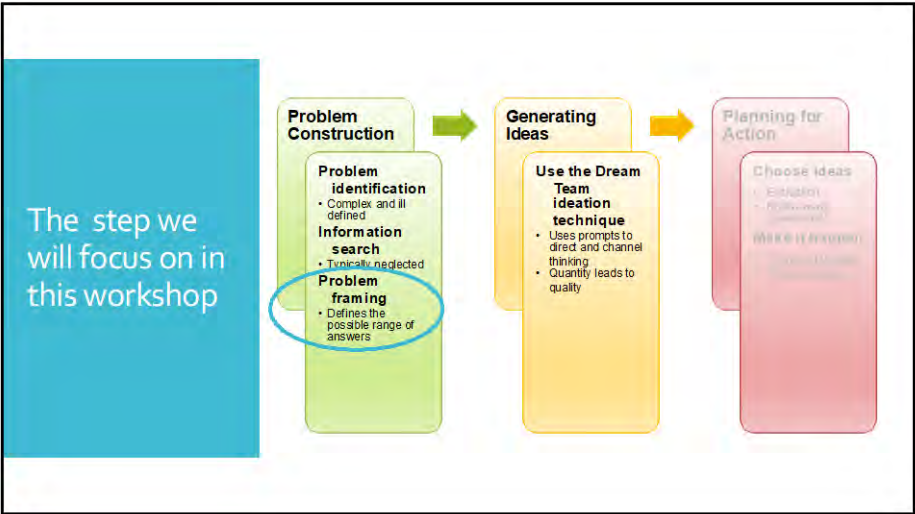
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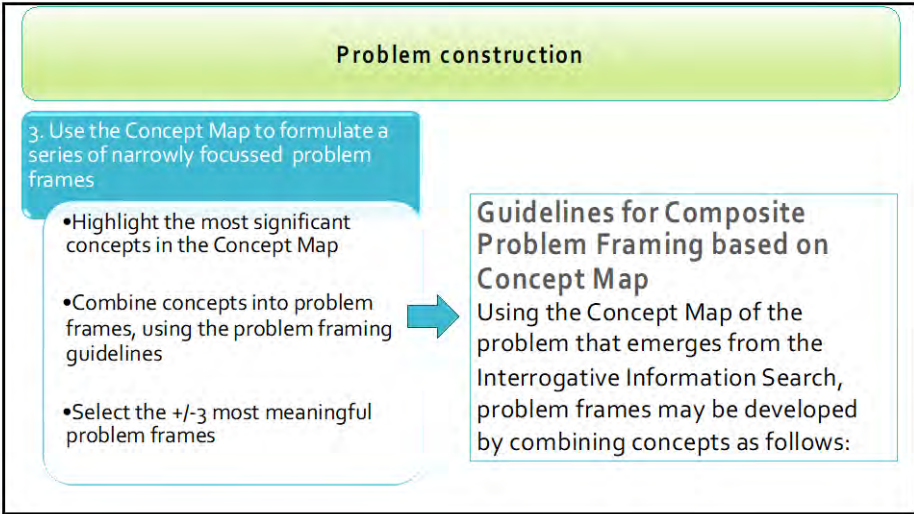
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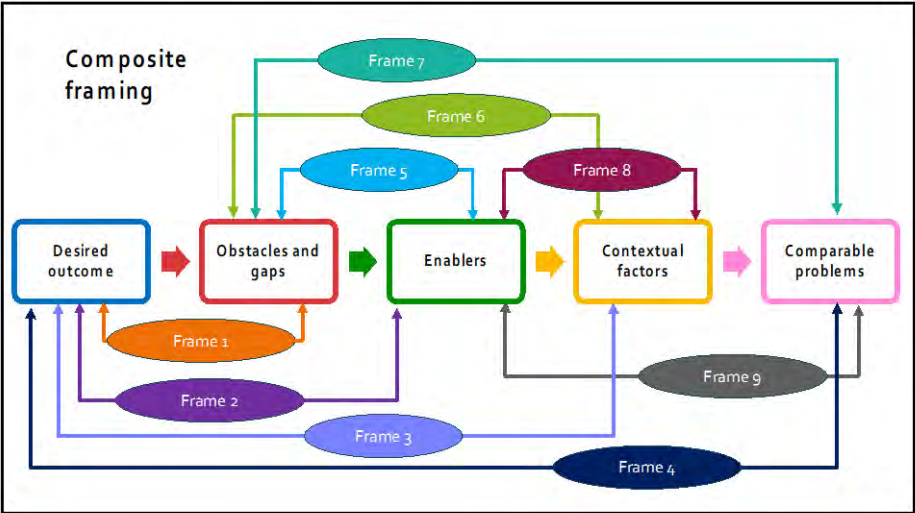
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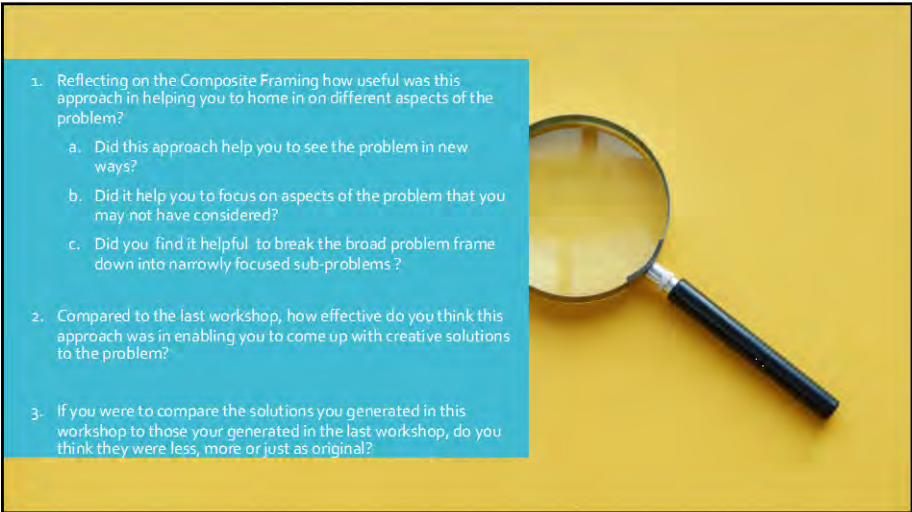
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Generating ideas using the Dream Team technique		
4. Generate ideas to address each of the focused problem frames • Use the DREAM TEAM ideation tool to generate creative solutions to selected focused problem frames	Diminish or Downscale Are there parts of the problem you can diminish or downscale?	Tailor Are there parts of the problem you can tailor to address specific needs/ purposes/ people?
	Resourcing Could you consider alternative resources for managing the problem, such as by outsourcing or partnering with others?	Emulate Are there examples of how this challenge or similar challenges have been addressed by others that you can learn from and emulate?
	Extract Are there aspects of the problem that can be extracted or eliminated?	Automate Is there a way you can harness or make better use of technology ?
	Add Is there a new element you could add or introduce to combine with existing elements?	Make Magic What can be done to add a spark of something special?
	Magnify Could you magnify or exaggerate any aspect(s) ?	

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4. If you were to compare the solutions you generated in this workshop to those you generated in the last workshop, do you think they were less, more or just as useful and practical?

5. Did you find the process we used today made you

- a. more interested in the problem itself?
- b. more motivated to solve it?
- c. apply your mind in a more focused and disciplined way?
- d. and how did this compare to your experience in the last workshop?

6. How effective did you find the steps you used to conduct Composite Framing?

- a. Were there any problems you had with applying this approach?
- b. Could you offer any suggestions as to what would have made it easier for you?

7. Do you have any additional feedback you can offer on the process you used?

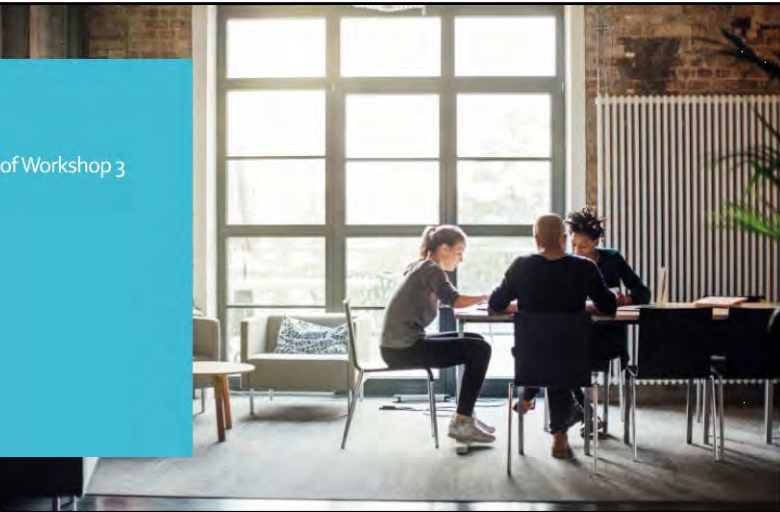


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One on One Interviews

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End of Workshop 3



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Workshop 4

Purpose

To use the full CPS process, that incorporates your inputs, on a new problem and then get your feedback on your experience

Objectives

- 1. Conduct an Interrogative Information Search on Problem 2
- 2. Working from the Concept Map, develop a set of narrow problem frames
- 3. Use the Dream Team to generate creative solutions to selected narrow frames
- 4. Discuss guidelines on how to plan for action (We will work with these to the extent that time allows)

➤ I will both facilitate and observe

➤ Let me know how effective you found this experience



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Reminder of how to use the Interrogative Information Search

1. The IIS Framework poses questions about the problem.

2. The aim of the IIS is to facilitate both a deeper and broader understanding of the problem.

3. Responses to certain questions may require further research as not all questions may be answered immediately.

4. Not all questions deserve equal attention for your problem. While some questions do need further consideration, even if at first they do not appear overly relevant, focus on answering the questions that you find most interesting and provocative.

5. Not all questions may be relevant, but if at first a question appears not to be relevant to the problem , attempt to probe whether this is indeed the case before moving on to the next question.

6. Questions should be addressed in the sequence prescribed by the framework, but If pondering latter questions evokes thoughts on questions already considered, go back to these questions and provide the relevant responses. Then resume reflecting on questions as per the sequence.

7. Responses to questions should be documented in the concept map as sub –topics. Answers should be highlighted to visually distinguish them from questions.

8. When particularly important concepts are noted, they should be flagged by noting this on the concept map and assigned a priority.

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Problem construction

3. Use the Concept Map to formulate a series of narrowly focussed problem frames

•Highlight the most significant concepts in the Concept Map

•Combine concepts into problem frames, using the problem framing guidelines

•Identify a systemic problem frame

•Select the +/-3 most meaningful problem frames

Guidelines for Systemic Problem Framing

1. Map relationships between key concepts using a Causal Loop Diagram format or similar visual map

2. Circle a pattern of relationships that cause or perpetuate a problem

3. Formulate problem statement aimed at disrupting the pattern of relationships

Generic problem statement: In what ways could this system be disrupted?

50

Example of a systemic problem frame

x

a

d

y

b

e

z

c

f

Problem statement:
In what ways can this system be disrupted?

Details have been excluded in this thesis to comply with RAM's confidentiality requirements

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Problem construction

3. Use the Concept Map to formulate a series of narrowly focussed problem frames

•Highlight the most significant concepts in the Concept Map

•Identify a systemic problem frame

•Combine concepts into problem frames, using the problem framing guidelines

•Select the +/-3 most meaningful problem frames

Guidelines for Composite Problem Framing based on Concept Map

Using the Concept Map of the problem that emerges from the Interrogative Information Search, problem frames may be developed by combining concepts as follows:

1. Combine concepts from Obstacles & Enablers
Generic problem statement: In what ways could this obstacle be addressed by drawing on this resource?

2. Combine concepts from Obstacles & Context
Generic problem statement: Given this contextual element, in what ways could this obstacle be addressed?

3. Combine concepts from Obstacles, Enablers & Context
Generic problem statement: In what ways could drawing on this resource assist in overcoming this obstacle, given this contextual element?

4. Combine concepts from Obstacles & Analogies
Generic problem statement: In what ways could learnings from this analogical situation be harnessed to overcome this obstacle?

5. Combine concepts from Enablers & Context
Generic problem statement: Given this contextual element, in what ways could this resource be better leveraged?

6. Combine concepts from Enablers & Outcomes
Generic problem statement: In what ways could this resource be used to address the needs of this stakeholder?

7. Combine concepts from Enablers & Analogies
Generic problem statement: In what ways could we emulate how this resource has been leveraged by others in this analogical situation?

8. Combine concepts from Outcomes & Context
Generic problem statement: Given this contextual element, in what ways could this stakeholder's needs be addressed?

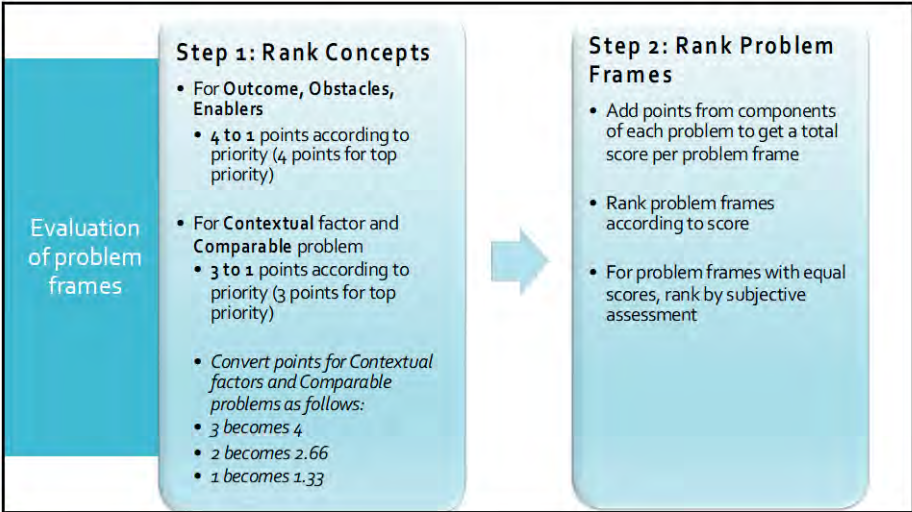
9. Combine concepts from Outcomes & Analogies
Generic problem statement: In what ways could we emulate how this outcome has been achieved by others in this analogical situation?

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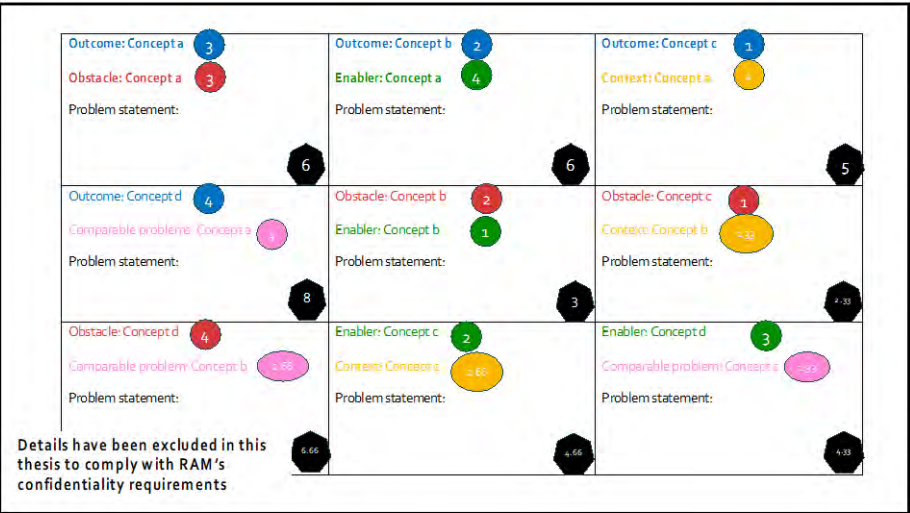
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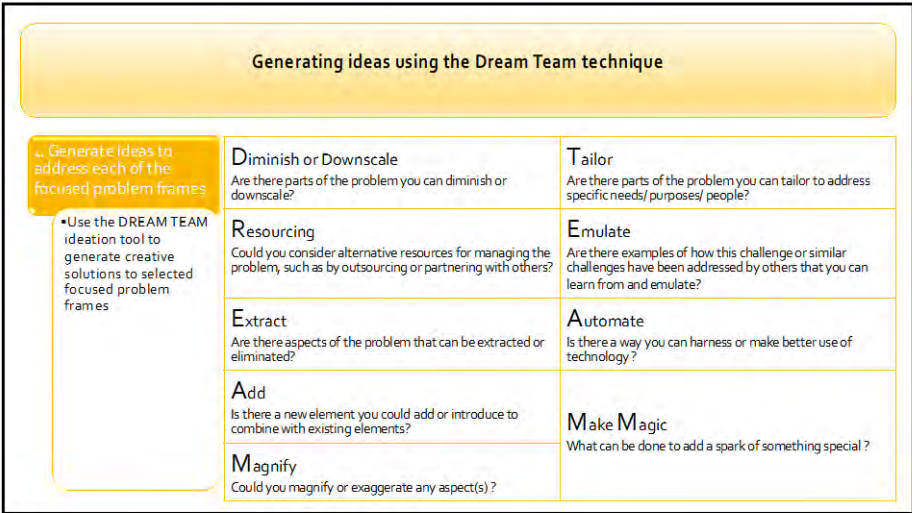
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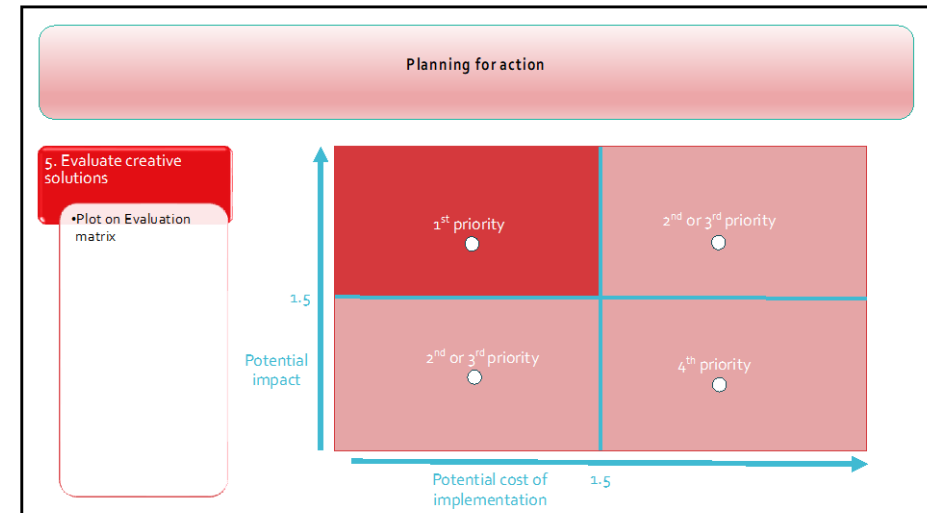


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APPENDICES

Planning for action		
5. Evaluate creative solutions	Evaluation Criteria	
	Rating (1=Low/2=Med/3=High)	
	Extent to which priority issues are addressed	
	Long term sustainability of impact	
	Benefits to stakeholders	
	Average rating	
	Cost Evaluation Criteria	
	Rating (1=Low/2=Med/3=High)	
	Direct financial cost	
	Resource intensity	
Time to implement		
Potential for disruption		
Average rating		

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Planning for action	
5. Evaluate creative solutions	Build on ideas with potential - Use the 6 thinking hats to explore each idea's potential - When ideas seem the same as something that has been done before, try to explore and expand on points of difference - Conduct risk/reward analysis - Explore what can be done to shape an impractical/good idea into something more workable/fabulous? - Build on benefits? - Tailor? - Strengthen/ reinforce weak points? - Simplify? - Re-evaluate potential impact and costs and revise plotting on Evaluation Matrix

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Planning for action	
6. Project planning	Prioritise creative solutions based on priorities suggested by second iteration of Evaluation Matrix Identify role players and sell/ co-opt them early Develop 'prototypes' Develop project plans - Plan timing for implementation of priority ideas and rank according to urgency - Identify stakeholders who need to buy in to the idea and those responsible for implementation - Ask for input to assist in scenario planning - Sell the idea by communicating benefits and sharing plans of alternate scenarios - Develop prototype before full scale development to test concept - Develop detailed project plans delineating timelines, resource requirements and accountabilities

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4th Focus group to discuss your experience

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1. Given that this is a problem you have grappled with before, did the IIS that we conducted reveal any new insights into the problem?
2. Did you find the conceptual map that we developed as a result of our IIS useful in representing the problem?
 - a. In what ways was it useful?
 - b. Did you find the level of detail in the conceptual map valuable or confusing?
3. A couple of people have mentioned to me that a challenge they sometimes encounter when trying to solve a problem, is that people may be resistant to having their opinions or ideas challenged. One of the aims of this approach is to encourage people to be more open to different ideas and opinions, rather than having to defend them. Based on your experience today, do you believe that the approach we used of asking a lot of questions about the problem helped to maintain open minds? Feel free to tell me if you don't think it helped.

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4. What was your experience of using the Composite Framing approach?
 - a. Was it easy enough to follow the steps, or did you find this too challenging?
 - b. Did the resultant problem frames pose different questions about the problem than you had asked before?
 - c. Did you find that using these narrow problem frames was useful in helping you to approach the problem in new ways? Or did you find them difficult to work with?
5. Do you think the approach we used today helped you to generate solutions that were any more original, when compared to solutions you may have come up with in the past when tackling this problem?
6. Do you think the approach we used today helped you to generate solutions that were any more useful and practical, when compared to solutions you may have come up with in the past when tackling this problem?
7. Is this an approach you might want to use again when trying to tackle a problem that needs a creative solution?
8. Do you have any suggestions as to how the approach or the process of applying it could be improved?

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One on One Interviews

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APPENDIX F: RESEARCH INSTRUMENTS USED IN ACTION RESEARCH

1. CYCLE 1

1.1 Discussion guide for focus group in Cycle 1

1. How effective do you think the creative problem solving process was in enabling you to come up with creative solutions to the problem?
2. How original do you think your suggested solutions were?
3. How useful and practical do you think your suggested solutions were?
4. Do you think this process supported you to develop deeper knowledge about the problem?
5. Do you think this process encouraged you to see this problem in different ways?
6. Did you find this process made you
 - a. more interested in the problem itself?
 - b. more motivated to solve it?
7. Did you find this process encouraged you
 - a. to be committed to solving the problem?
 - b. to apply your mind in a focused and disciplined way?

1.2 Questionnaire for personal interviews in Cycle 1

The purpose of this interview is to find out how you think this process may or may not help you improve your creative problem solving as a team and as an individual, and to find out if there are any suggestions you may have in this regard.

I'd like to ask you to think about your experience in trying to come up with creative solutions in the past.

1. Have your attempts to come up with creative solutions in the past been conducted mainly as a team or on your own?
2. When it was as a team, what worked well and what challenges did you encounter?
3. To what extent do you think the approach we used today might be helpful in improving your creative problem solving as a team?
4. What else do you think could be done to improve the effectiveness of your team dynamics in creative problem solving?

5. When you worked on your own to come up with creative solutions, what worked well and what didn't work well?
6. To what extent do you think the approach we used today might be helpful in improving your creative problem solving when working on your own?
7. What else do you think could be done to help you to be more effective in creative problem solving when working on your own?

2. CYCLE 2

2.1 Discussion guide for focus group in Cycle 2

1. Reflecting on the Interrogative Information Search, how useful were the questions in expanding your understanding of the problem?
 - a. Did this process help you to get a deeper understanding of the problem?
 - b. Did this process help you to get a broader understanding of the problem?
 - c. Did the questions make you more curious about the problem?
 - d. Did the questions follow on from each other logically?
2. Compared to the last workshop, how effective do you think this approach was in enabling you to come up with creative solutions to the problem?
3. If you were to compare the solutions you generated in this workshop to those your generated in the last workshop, do you think they were less, more or just as original?
4. If you were to compare the solutions you generated in this workshop to those your generated in the last workshop, do you think they were less, more or just as useful and practical?
5. Compared to the last workshop, were there any differences in the extent to which you felt supported to
 - a. try different approaches to thinking about this problem?
 - b. and see it in different ways?
6. Did you find the process we used today made you
 - a. more interested in the problem itself?
 - b. more motivated to solve it?
 - c. apply your mind in a more focused and disciplined way?
 - d. and how did this compare to your experience in the last workshop?
7. Do you have any additional feedback you can offer on the process you used?

2.2 Questionnaire for personal interviews in Cycle 2

The purpose of this interview is to find out how you think this approach to looking for information about the problem may or may not help you improve your creative problem solving as a team and as an individual, and to find out if there are any suggestions you may have in this regard.

1. To what extent do you think the approach we used today might be helpful in improving your creative problem solving as a team?
 - a. Any suggestions as to how the process could be improved to better support effective teamwork?
2. To what extent do you think the approach we used today might be helpful in improving your creative problem solving when working on your own?
 - a. Any suggestions as to how the process could be improved to better support your individual creative problem solving?
3. To what extent has answering these questions helped you to see your problem differently?
4. Which (if any) questions or aspects of the framework helped you to think of your problem differently or find a new angle or perspective on your problem?
5. Did any new questions emerge for you as a result of your information search?

3. CYCLE 3

3.1 Discussion guide for focus group in Cycle 3

1. Reflecting on the Composite Framing how useful was this approach in helping you to home in on different aspects of the problem?
 - a. Did this approach help you to see the problem in new ways?
 - b. Did it help you to focus on aspects of the problem that you may not have considered?
 - c. Did you find it helpful to break the broad problem frame down into narrowly focused sub-problems ?
2. Compared to the last workshop, how effective do you think this approach was in enabling you to come up with creative solutions to the problem?
3. If you were to compare the solutions you generated in this workshop to those your generated in the last workshop, do you think they were less, more or just as original?
4. If you were to compare the solutions you generated in this workshop to those your generated in the last workshop, do you think they were less, more or just as useful and practical?
5. Did you find the process we used today made you
 - a. more interested in the problem itself?
 - b. more motivated to solve it?
 - c. apply your mind in a more focused and disciplined way?
 - d. and how did this compare to your experience in the last workshop?

APPENDICES

6. How effective did you find the steps you used to conduct Composite Framing?
 - a. Were there any problems you had with applying this approach ?
 - b. Could you offer any suggestions as to what would have made it easier for you?
7. Do you have any additional feedback you can offer on the process you used?

3.2 Questionnaire for personal interviews in Cycle 3

The purpose of this interview is to find out how you think this approach to problem framing may or may not help you improve your creative problem solving as a team and as an individual, and to find out if there are any suggestions you may have in this regard.

1. To what extent do you think the approach we used today might be helpful in improving your creative problem solving as a team?
 - a. Any suggestions as to how the process could be improved to better support effective teamwork?
2. To what extent do you think the approach we used today might be helpful in improving your creative problem solving when working on your own?
 - a. Any suggestions as to how the process could be improved to better support your individual creative problem solving?
3. To what extent has this approach to problem framing helped you to see your problem differently?
4. Which (if any) specific aspects of this approach helped you to think of your problem differently or find a new angle or perspective on your problem?

4. CYCLE 4

4.1.1 Discussion guide for focus group in Cycle 4

1. Given that this is a problem you have grappled with before, did the IIS that we conducted reveal any new insights into the problem?
2. Did you find the conceptual map that we developed as a result of our IIS useful in representing the problem?
 - a. In what ways was it useful?
 - b. Did you find the level of detail in the conceptual map valuable or confusing?
3. A couple of people have mentioned to me that a challenge they sometimes encounter when trying to solve a problem, is that people may be resistant to having their opinions or ideas challenged. One of the aims of this approach is to encourage people to be more open to different ideas and opinions, rather than having to defend them.

Based on your experience today, do you believe that the approach we used of asking a lot of questions about the problem helped to maintain open minds? Feel free to tell me if you don't think it helped.

4. What was your experience of using the Composite Framing approach?
 - a. Was it easy enough to follow the steps, or did you find this too challenging?
 - b. Did the resultant problem frames pose different questions about the problem than you had asked before?
 - c. Did you find that using these narrow problem frames was useful in helping you to approach the problem in new ways? Or did you find them difficult to work with?
5. Do you think the approach we used today helped you to generate solutions that were any more original, when compared to solutions you may have come up with in the past when tackling this problem?
6. Do you think the approach we used today helped you to generate solutions that were any more useful and practical, when compared to solutions you may have come up with in the past when tackling this problem?
7. Is this an approach you might want to use again when trying to tackle a problem that needs a creative solution?
8. Do you have any suggestions as to how the approach or the process of applying it could be improved?

4.1.2 Questionnaire for personal interviews in Cycle 4

The purpose of this interview is to find out how you think the IIS and Composite Framing may or may not help you improve your creative problem solving as a team and as an individual, and to find out if there are any suggestions you may have in this regard.

1. To what extent do you think the IIS and Composite Framing we used today might be helpful in improving your creative problem solving as a team?
2. Are there any changes you'd suggest to the IIS and Composite Framing to make it more effective when you use it as a team?
3. To what extent do you think the IIS and Composite Framing we used today might be helpful in improving your creative problem solving when working on your own?
4. Are there any changes you'd suggest to the IIS and Composite Framing to make it more effective when you use it on your own?

5. QUESTIONNAIRE USED TO ASSESS MEDIATING VARIABLES IN CYCLES 2 AND 4

1. I knew what the different aspects of this problem were
2. I understood the obstacles to resolving this challenge
3. I appreciated the complexity of this challenge
4. I understood the most critical issues that need to be addressed
5. I understood the finer details of this issue
6. I looked at this issue from many angles
7. I considered many potential solutions
8. I thought about this issue from other peoples' points of view
9. In evaluating potential solutions, I played out different scenarios in my head
10. I considered how potential solutions may or may not work under different circumstances
11. I enjoyed the process of solving this problem
12. I thought of this as a really interesting problem to try and solve
13. I thought of this as a challenge worth solving
14. I found myself absorbed in the process of trying to solve this problem
15. I thought I would be interested in spending more time trying to solve this problem
16. I kept trying to come up with new ideas even when I found it difficult
17. Even after I had come up with some good ideas, I kept digging deeper to come up with better ones
18. I blocked out any distracting thoughts to ensure I was fully focused on the relevant issues
19. When an idea occurred to me, I thoroughly explored all the ways in which it could play out
20. I made sure that I examined all relevant aspects of the problem thoroughly

Response format in Qualtrics

	Much less than on the last attempt	Less than on the 1st attempt	A little less than on the last attempt	The same as on the last attempt	A little more than on the last attempt	More than on the last attempt	Much more than on the last attempt
	1	2	3	4	5	6	7
Click anywhere along this line to indicate your response							