Choose Your Creativity: Why and How Creativity in Requirements Engineering Means Different Things to Different People

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Abstract. [Context and Motivation] The word "creativity" is used widely in business and academia, but its meaning may differ greatly depending on context. This may cause confusion in the minds of requirements engineers who have to determine which kinds of creativity are relevant to their project and which creativity tools to use. **[Question/Problem]** The main goal of this work is to understand why and how the meaning of the word "creativity" varies, and study the impacts of these variations on requirements engineering. **[Principal ideas / results]**. A comparative review of creativity-related literature from Social Sciences and Requirements Engineering was performed. **[Contributions]** This study results in a new framework for understanding the precise local meaning of creativity used in a specific context, before deciding on the adequate support for it. Since creativity in RE is still a relatively new topic, research directions are also proposed.

1 Introduction

Creativity is now recognised as an important topic in Requirements Engineering (RE) [1]. However, it is still a fuzzy concept for the Requirements Engineer (REer). Consider, for example, that at the kick-off meeting of a new development project, the sponsor emphasised the importance of creativity. Now, as the REer on this project, you feel in trouble: are you supposed to get together in a funny workshop using sticky notes? Or are you supposed to use new technology? Do you have to make a revolution in your product line? Or do you have to find new ways of collaborating? Are you supposed to take risks? Should you challenge the very problems you are asked to solve?

As this story indicates, there are many ways one could be creative during the development of a socio-technical system, and many ways one could support creativity during the project. In its early phases, the REer will manage an important part of the creativity on the project. So the REer has to choose a certain creativity, and find ways to support it. The Research Question of this paper can be formulated this way:

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RQ: How can we help the REer to find the adequate creativity for a project?

To address this question, this paper proposes an actionable framework that the REer can use to guide interviews with projects sponsors, and to structure the results in a way that a specific creativity is determined.

After a brief description of the method (Section 2) and related work (Section 3), the rest of this paper summarises the history of the understanding of creativity in the Social Sciences (Section 4). It then reviews the definitions of creativity in RE (Section 5), and introduces a two-dimensional framework meant to explain *why* and *how* the meaning of creativity varies in RE (Section 6). Concrete usage of the framework in practice is also discussed (Section 7). Finally, creativity in RE is re-examined in the light of the proposed framework, which triggers various questions and new research directions (Section 8).

2 Method

In order to grasp what was lacking in REer's understanding of creativity in general (a pre-requisite to understanding the creativity needed on his specific project), a comparative literature review on creativity in RE and in other fields was performed. Doing so, the authors realized that bringing a summary of the understanding of creativity in social sciences would benefit to the RE community. During the review, the authors also gathered elements that had an influence on creativity, as well as elements characterizing creativity itself, and analyzed which of these would apply to RE. The first were called *contextual factors,* and the latter *dimensions*, and were summarized in the framework described below.

The comparative review involved selecting appropriate papers in many disciplines. RE literature was initially collected from reference databases (DBLP [3], Google Scholar [4]) using keyword searches. These initial results were manually filtered from an analysis of the abstracts. Snowballing (discovery of new papers through analysis of a paper's references) was then applied until no new significant reference could be found.

For the other disciplines, the sheer volume of multi-disciplinary creativity-related literature made rigorous analysis impractical. For the Social Sciences, Keith Sawyer's book "Explaining Creativity" [5] was used as a guide. This recent book, rich with approximately 500 references, sets out to be a summary of what is known in the field about creativity. This prominent source introduces bias in this study. It was however judged preferable to be biased by a recognised figure in the field than by the inevitably superficial analysis that would have otherwise been made. The survey was complemented by literature from Design, Management Sciences and the Arts.

3 Related Work

This work builds on existing work, which is referenced throughout the report, so citing all sources here would be redundant. However, the relationship with Nguyen and Shanks' framework for understanding creativity in RE [6] merits specific

explanation. The two studies share initial goals (understanding creativity in RE) and many opinions, but also partly diverge in their results. This work uses different sources, leading to a separate model and new research directions. Although there are significant overlaps with Nguyen and Shanks, the architecture and formulation of the frameworks are quite distinct. They suggest creativity can be understood by analysing in turn the creative *product*, the *process* leading to that product, the *people* behind that process, the *domain of application* and the *context* surrounding the project. In contrast, the present study structures its framework in such a way that contextual factors and creativity dimensions are distinguished, and the interactions between factors and dimensions are emphasized. This study does not claim more validity than Nguyen and Shanks' study, but rather suggests another viewpoint that is likely to be complementary. An empirical comparison would be helpful to assess the applicability of each of these frameworks in specific situations.

4 A Brief History of Creativity in the Social Sciences

In his book *Explaining Creativity* [5], Sawyer describes the history of the understanding of creativity. Starting in the 1950's, psychologists tried to define creativity as a personality trait. Consequently they attempted to measure it, similarly to using an IQ test to measure intelligence. By the 1970's, their failure was clear, and it convinced many psychologists that creativity is not a distinct personality trait or mental process, but a combination of everyday cognitive processes [5]. Studies that tried to relate creativity to mental illness or to explain creativity based on the brain's biological components failed for the same reasons; that creativity is not a personality trait. Another reason for psychologists' failure to define creativity is that creativity is a culturally and historically specific idea that changes from one country to another, and from one century to another (as noted by Sawyer [5]).

Understanding that creativity was a combination of more basic cognitive processes, cognitive psychologists studied and analysed creativity as a process. Major contributions include those from Wallas [7] and Hadamard [8], who argued that creativity involved four main phases: *preparation* (accumulation of knowledge), *incubation* (cognitive release), *illumination* (the "aha", or "eureka" moment) and *verification* (evaluation and elaboration of ideas). Boden [9] explained three possible phases that the human brain experiences during a creative problem solving process: *exploration* of a possible solution space, *combination* of two or more existing ideas, and *transformation* of the solution space to make previously impossible things possible. More pragmatic contributions include those from Osborn (Brainstorming, Creative Problem Solving (CPS)) [10] and Gordon (Synectics) [11] who developed processes for creative problem solving.

While cognitivist models have proven useful, criticisms exist, in particular towards the sequential nature of the aforementioned creativity process. Some researchers (such as Rothenberg and Vinacke in [5]) argue that Wallas' phases are not easy to distinguish from one another in practice, and adopt an approach where all the steps are quasi-concurrent in the creative person's head, describing very short cycles. The single important illumination moment is also replaced by many mini-insights,

supported by hard work (Weisberg in [5]). To illustrate this, they take the example of a painter, whose creativity is developed as a back-and-forth movement from an idea in the head to its elaboration as a set of brushstrokes, and the immediate evaluation (judging the observable result) that will lead to the next idea. Cycles are very short, so that the elaboration and evaluation instantly feed back into the preparation process. This is similar to the work of Philosopher John Dewey [12], who suggested in 1910 that human thought is a continual repeating cycle of problem, solution and evaluation.

By the 1980's, psychologists started to think that they needed the help of other social sciences (such as sociology, anthropology and history) to understand creativity. This lead to the adoption of a sociocultural approach, defined as follows [5]: creativity is specific to a *domain*, of which the existing artefacts and conventions are the input to the creative *person*'s own work; the latter will then be judged as creative or not by influential people: the *field*. The creative artefact, new in its domain and judged valuable by the field, is then added to the domain. The creative person is one that is able to come up with such artefacts. Research, artistic disciplines and business all require an explanation of the sociocultural approach to creativity [5]. Many authors share this view, but fail to emphasize the importance of domain and field, and rather add an emphasis on *surprisingness*. For example, Boden suggests that creativity is the ability to come up with ideas or artefacts that are new, surprising and valuable [9]. Similarly, Sternberg and Lubart define creativity as the ability to produce work that is both novel (original and unexpected) and appropriate [13].

In the sociocultural view, the short creative cycles in the creator's head are embedded in a macro-cycle at the level of the sociocultural entity formed by the person, domain and field [5]. As in a fractal, the small follows the same pattern as the large. For example, in painting, each brushstroke entails preparation, incubation, illumination and verification. The final painting follows the same cycle. Indeed, the artist lives in a society that possesses a culture, is aware of centuries of painting tradition, and continuously exchanges with peers in one way or another (*preparation* and *incubation*). Then, once the canvas is painted (*illumination*), gallerists evaluate it and chose to promote it. This selection provides feedback on what is valuable, which is complemented by the public choices (*verification*). This endorses the view that, even in disciplines like painting that are known to be solitary, no creative work exists in isolation, as our interactions with the field and the domain are important contributors to the creative process [14]. Collaboration is absolutely central to creativity in the sociocultural view [5], [15]. As Graham Bell stated: "*Great discoveries and improvements invariably involve the cooperation of many minds!*" (cited in [5]).

These advances led some researchers to focus on group creativity while their predecessors had mainly focused on the individual [5]. Their use of the sociocultural model challenged one of the main western myths about creativity: that it is the result of an unconscious dream of a lone unrecognized genius having a sudden burst of insight [5]. The sociocultural view argues that creativity is a collaborative, social phenomenon that requires hard work and is made of many mini-insights [5], [15]. It suggests that group creativity is qualitatively different from individual creativity, and it must be analysed as a collective social phenomenon, incorporating concepts from sociology, communication and organizational behaviour [15].

5 A Review of Creativity Definitions in RE Literature

The DBLP [3] database returns around 700 publications for the main RE source, the IEEE "RE" conference series. Selecting papers using the search query "creativ" OR "invent" OR "innovat" in the title returns only 13 papers. As a comparison, the word "goal" yields 45 references, and the word "scenario" yields 39 references. This gives a crude indication of the maturity of the creativity sub-field within RE.

Many of the RE authors have chosen a simple interpretation of the sociocultural definition for creativity; that creativity is something novel and valuable. However, they frequently omit definitions of the terms *novel* and *valuable*, and rarely mention the *person-domain-field* triad. Consequently, the emphasis on collaboration that the sociocultural approach suggests is also neglected in most cases. For example Jones *et al.* [16] cite [9] and [13] above, while Nguyen and Shanks [6] chose *novelty*, *value* and *surprisingness* as three characteristics of the creative outcome in RE. Mich *et al.* [17] also insist on surprisingness, Regev *et al.* use the sociocultural *person-domain-field* model, and add this intuitive formulation: *"Creative as the contrary of usual, obvious, i.e. unexpected, unusual, new. Independent thinking. Taking distances from the rules. Breaking the norms (…)"* [18]. Pennel and Maiden formulate this practical definition: "*From a practical point of view, generating genuinely creative ideas was less important than to enable participants to produce ideas for requirements that would not normally have been elicited*." [19].

Maiden *et al.* [1] resolve the creativity definition problem by using the proxy of the Creative Problem Solving (CPS) process [10], a framework that suggests a series of steps to follow in order to be creative. Taking this view, any discipline that follows the CPS is likely to be a creative discipline. Therefore, if a software development project follows the CPS in the earlier stages corresponding to RE, then the project must be creative. They propose a way to measure the novelty of requirements, by computing dissimilarity between new requirements documents and existing ones. This ongoing research is expected to help define what *novelty* means for requirements.

Nguyen and Cybulski [20] chose an alternate view of creativity. They see it as an act of constructivist learning; an authentic and (inter-)personal construction of knowledge. Their model involves three dimensions: *endogenous* (learning from the inner self), *exogenous* (from others) and *dialectic* (with others). They argue that in order to be creative, both analysts and developers must become learners in their application domain and in the domain of general problem solving.

Nguyen and Shanks [6] argue that "*Creativity in problem solving involves individuals engaged in a cognitive and social collaborative process to produce a novel and valuable outcome, which will be subject to evaluation within a specific domain and social context.*" This perspective is clearly indebted to the sociocultural definition of creativity, by acknowledging the importance of collaboration and the *de facto* situated character of creativity. Ocker focused on the development of distributed computer systems to support group interaction. Consequently, his definition of creativity looks at the collaborative side of creativity: "*Creativity is a complex interaction of person and situation that takes place at both the individual and group levels*." [21].

6 Why and How the Meaning of Creativity Changes

Creativity is all about bringing something new in a domain, which will be judged valuable by a field. However, the breadth of discussion on this simple definition in the Social Sciences suggests that creativity cannot be reduced to a single clear concept. For a REer, it is important to define creativity for a particular organisation, or for a particular project within that organisation, or even for a particular moment within a project. Indeed, within each project, combinations of different creativities appear to be the most likely reality.

This section reports three *contextual factors* that explain *why* creativity can be understood differently in RE, and five *dimensions* that explain qualitatively *how* creativity's meaning can vary in RE. Together they form a conceptual framework for choosing and defining a project-specific creativity, which is represented graphically on Figure 1. For each of the fifteen combinations of contextual factor and dimension, there are possibly two important questions to ask. The first assumes a given context: "*In what context am I working, and how does that impact this dimension of creativity for me?*". The second goes in the reverse direction, and assumes that one has specific goals for creativity: "*What is my desired value for this dimension, and how should I change my context consequently?*". In practice, both context and goals are likely to be partly given and partly free to define. In any case, both have to be discovered in order to choose a specific creativity. Consequently, we expect that the practitioner will at times ask the first question, at other times the second, and frequently both.

Below, each of the contextual factors and dimensions are presented and discussed in detail. As for now, this study only points the practitioner to good questions he should ask. It illustrates the relevance of these questions by briefly discussing the likely interactions between contextual factors and dimensions (labelled with *"Interactions:"* at the end of each of the sub-sections in section 6.2). It must be understood that these questions may be extremely difficult to answer. For example, the contextual factor "culture" is probably an even broader concept than creativity is. So understanding the interactions between both can be a very tricky job, and certainly is for a REer who is not a specialist of these questions. In the future, it is hoped that research can help in giving good answers to these good questions. To this end, this paper systematically suggests appropriate Research Agenda items (numbered with "*RAx:*" at the end of each of the sub-sections in sections 6.1 and 6.2).

6.1 Contextual Factors

Culture. Culture is the set of shared values, goals, attitudes, and practices that characterises a group of people. Culture is subject to changes over time. As mentioned above, the notion of creativity depends on culture and history [5]. For example, before the Renaissance, a creative painter was one who was able to accurately reproduce nature. In traditional cultures, artistic creativity was linked with the ability to communicate with superior spirits. In modern western cultures, an artist's creativity is often seen as the exteriorisation of their unique inner self.

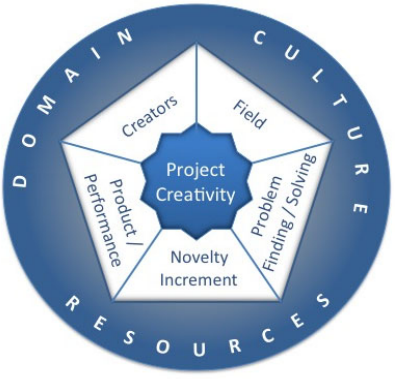

Fig. 1. Three contextual factors and five dimensions for creativity in RE

In recent years, the way organizations undertake creative efforts has changed, including in the software industry, and consequently in RE. For example, Yilmaz discusses modern conceptions of creativity in Software Engineering, such as collaborative creativity, open innovation and socio-technical ecologies [22]. The creativity that REers must consider on a project is likely to be very different today than five or ten years ago. Additionally, not only does each organization have a unique culture, but each of its sites might have a different way of implementing that culture, and each project will have its own "local" culture. For these reasons, cultural impacts ensure that no two RE projects ever have the same relation to creativity.

All the definitions of creativity used in RE literature assume a modern, western vision of creativity. This is implicit and most likely due to the fact RE research essentially exists in the modern western culture. Sawyer argues that a characteristic of the modern western vision of creativity is its focus on originality, in the sense of "uncommon" or "surprising" [5]. Originality is also a key requirement for academic excellence, and industry sometime argues that originality must precede value. In the RE literature, creativity definitions emphasise words like "surprising" and "not normal". What is not clear, however, is why RE creativity is so interested in surprise. Is it rational to have a preference for *unexpected* value (surprise) over *expected* value (no surprise)? Surprise is a scary word for some managers [18]. Some of them even reject creativity upfront as they think it is *novel and surprising* instead of *novel and valuable,* as defined in the sociocultural definition of creativity above. It appears that cultural bias might play an important hidden role here.

This discussion leads us to identify the following research agenda (RA) items:

RA1. Explore the relationship between culture and creativity in RE.
RA2. Is RE research biased towards surprisingness? If so, what are the positive and negative consequences of this bias?

Application Domain. Authors like Baer and Kaufman [23] suggest that creativity entails both domain-independent and domain-specific elements. Domain-independent factors include characteristics and skills such as intelligence, motivation and openness. These imply that some personality traits will help you to be creative in more than one domain.

On the other hand, domain-specific factors are things that must be known about a domain in order to bring something new and valuable to it. These imply that a creative cook is not necessarily creative in science or music. This is consistent with the sociocultural view of creativity that requires a domain to define creativity. Consequently, when REers change their application domain, they change the nature of creativity. Furthermore, all application domains (video game industry or medical software, for example) have their own characteristics, including: a unique culture; a specific way to interact with a market; a level of competition; an innovation rate; an acceptable risk level. All of these factors, and more, drive different kinds of creativity for the REer to consider.

The application domain has an important influence on the whole software development process, including RE [24]. REers should be able to tailor RE processes to specific projects and situations. As soon as a project is different from the previous one to some degree, the RE process might also have to be novel to some degree, and hopefully be as valuable as possible. Building the right RE process is perhaps the first creative task for the REer. Some might argue that this is the most important, or even the *only*, place where the REer is responsible for the content of a creative artefact. This view is consistent with the Participatory Design view where requirements are the collective responsibility of the stakeholders, including the REer as a facilitator [25]. In this view, the REer should be as neutral as possible in terms of content, but as active as possible in the role of catalyst for value creation. This initiates discussion on the role of the REer who is, depending on the point of view, a translator, a discoverer, a business expert, a learner, an inventor, a facilitator, or some combination of these. The broader understanding of creativity reopens this important discussion, and offers a new point of view. In the RE literature, only Cybulski *et al.* [26] explicitly distinguish between the domain-specific and general abilities needed to be creative. They argue that research should clarify the distinctions, and education should support both explicitly.

RA3: Explore the relationship between Application Domain and creativity.
RA4: Explore the role of the REer in the creative process.
RA5: Clarify the distinction between general and domain-specific creative abilities in RE.

Resources (time, money, skills). The amount of resources available for a project will inevitably influence creativity. However, this relationship is certainly not as simple as "no money, no creativity". Indeed, money and time-pressure could be factors, or even triggers, for certain kinds of creativity. Studies have shown that recent movies budgets had no correlation with best picture awards and were negatively correlated with critical acclaim [27]. Cowen and Tabarrok [28] discuss how money and other resources lead artists to adopt different creative styles. In terms of human resources, it is implicit that group creativity can only be used when there is more than one participant available, and that any creative effort relies on suitable skills.

Lack of resources is a major factor preventing REers from producing good quality work in general [29]. Research on more resource-efficient RE techniques is in progress [30]. However, RE authors have different opinions on the impact of resources on creativity. Maiden *et al.* [1] recall that incubation requires time and that external consultants cost money, so lack of resources is a barrier to creativity in their view. While Gorshek *et al.* [31] recognise that innovation-driven requirements compete for resources with the day-to-day urgent requirements, they propose a

lightweight creativity style to deal with that barrier. Finally, Regev *et al.* [18] take an opposite stance and claim that ample resources may not encourage creativity at all. Fricker and Seyff [30] suggest that smart collaboration processes and novel ways of doing RE can be the basis for increasing the productivity of requirements engineering, while reducing the required effort. Given these issues, it seems logical that RE should follow other disciplines and recognise that different quantities and types of resources will lead to different forms of creativity.

RA6: Explore the relationship between resources and creativity in RE.

6.2 Dimensions

The Creative Group. There is a qualitative difference between individual and group creativity [15]. The creative process in a person's head has only little similarity to the creative process within a group. Activities and outcomes are different. The relationship between creative individuals and creative teams is not simple; for example, the fact that brainstorming is usually inefficient [32] shows that it is not enough to put creative people together to have a creative team. The size of the group matters, as well as the way the members interact. Is the group a small informal group, a company, a community of interest, or the human society as a whole? Each group will have its own understanding of creativity and its own way to handle it.

Many authors claim that RE is essentially a collaborative social endeavour. For example, according to Arias *et al.* [33] and Boehm *et al.* [34], requirements emerge from the interactions, sometimes the conflicts, in the stakeholders group. Coughlan and Macredie [35] therefore adopt a more collaborative and emergent view of requirements elicitation. Holtzblatt and Beyer state: "*All aspects of Requirements definition ultimately succeed or fail based on how well people work together"* [36]. Having studied creativity workshops in some depth (see [37], for example), Maiden and colleagues also argue that collaboration is key in RE creativity. Maiden *et al.* [1] suggest tools and trainings to support collaboration, a research track that they continue to pursue. Through the constructivist learning framework, Nguyen and Cybulski [20] clearly distinguish between individual and collaborative creativity, and suggest that specific support is required for each. Innovative research in this direction was recently showcased at the RE conference [38].

The arguments above suggest that this dimension deserves particular attention in the RE domain. However, Nguyen and Shanks [6] stress the particularly low level of understanding of collaboration-centric processes. They identify this topic as a major research challenge, a view that is shared by the authors. Group creativity theories already exist [15] and could be transferred to RE to address this challenge.

Interactions: Some cultures promote individuality, some actively foster collaboration, others will be in between. In some domains, the complexity of interdependent systems will leave no other choice than explicit company-wide or even inter-company collaboration. In other domains, it will be possible to innovate alone. Collaboration is likely to require both time and skilled people, but in the appropriate circumstances, collaboration could be a way to save resources.

RA7: Explore how to support collaborative creativity in RE.

The Field. Authors see different types of creativity depending on the scale of the social recognition of the creative work [9], [39], [40]. The literature discusses the *field* and its *size*. Creativity ranges from everyday insights that an individual experiences (the field is just the creator); through hobby-level creativity (the field is a small local group of pairs); the creativity of the talented professional (the field is a set of important people working in an area); to creativity that leaves the creator's name in history (the field consists of thousands of people). For the socio-culturalists, creativity is by definition always relative to its field. For example, the fact that a movie can be a box office success while not being acclaimed by the critics [27] is a sign that creativity is specific to its field.

The size of the field is discussed by a number of RE authors. Maiden *et al.* [1] and Nguyen and Shanks [6], for example, use Sosa's *situated* creativity [39]. Some authors ([18], [19]) perceive that the typical RE project's *field* is made of the project stakeholders, and the *domain* is restricted to the existing ideas and products in the company. This is perhaps more likely to be the case for the development of bespoke products and services. In market-driven contexts, the domain corresponds to the products already on the market, and the field is made of the many people in the market, from a small number of big clients to many thousands of retailers and end-users. Neither is more genuinely creative than the other, but they require different strategies towards creativity.

Interactions: Most application domains have a particular market structure. However, in many cases a project/organisation can choose the target market, for example choosing a specific niche versus going worldwide. Large field innovation is likely to require more resources, and culture will play an important role in such choices.

RA8: Explore how to support creativity in RE depending on the size of the field (for example in custom versus market driven contexts).

The Size of the Novelty Increment. Many authors of business-oriented creativity research make a distinction between creativity leading to *incremental* innovation ("evolution"), and creativity leading to *radical* innovation ("revolution") [41–43]. The difference is that, in radical innovation, there is a major break with the domain's current conventions. This intuitively suggests that the risk of non-acceptance is higher, but the potential pay-off is higher, too. Management Sciences acknowledge the need for a balance between exploration and exploitation [43], and stress that both are needed for creativity [42].

Regev *et al.* [18] discuss innovation in the light of the change it causes for adopters. They stress the need to control the size of the increment to balance novelty and stability in the adopting organisation. They argue that an idea will be accepted if and only if the risk of accepting it is less than, or equal to, the risk of rejecting it. Mich *et al.* [17] suggest that creativity can be seen as a threat too, and Dallman [44] experimentally analysed willingness to take risk and conformism as factors influencing the creative process. However, the authors are not aware of any study that compares RE creativity support for evolution versus revolution.

Interactions: Culture is likely to have a significant impact on the novelty increment. Some organisations define themselves as "big innovators" while others find a way to make products cheaper. Innovation must not always be seen as desirable, and creativity

might then simply be a question of having the right mindset to solve conflicts more efficiently. More mature application domains may make revolution harder, while newer market segments might see revolutionary shifts every week. All else being equal, bigger novelty increments are likely to require more resources.

RA9: Explore creativity support depending on the size of the novelty increment.
RA10: Explore how to define the ideal balance of evolution/revolution on a project.

Performance and Product-Orientation. Sawyer [15] studied the difference between *performance-oriented* creativity and *product-oriented* creativity. In performance-oriented creativity, there is no tangible product at the end of the creation process, since the process itself *is* the deliverable. A jazz concert is an example of performance-oriented creativity, while writing a book is an example of a product-oriented creative process. Sawyer argues that most creative genres use a combination of both.

There appear to be no RE authors who explicitly make the above distinction. Perhaps under the influence of the prevailing business culture, RE has implicitly focused on product-related creativity. However, requirements workshops can certainly be considered as a group performance, just like a musical or theatre show [15], [45]. Ellen Gottesdiener [46] advises on how to run requirements workshops. Although she does not refer to the work on group creativity discussed above, her advice is largely consistent with it. Workshops are an important technique in RE [46], together with other human-interaction intensive techniques like interviews. Consequently, there are good reasons to be interested in performance-related creativity. Depending on one's RE process or methodology, there will be more or less performance moments. REers have to choose the right mix of performance-oriented and product-oriented collaboration moments.

In his study of group performances [15], Sawyer suggested that any performance relies on some structure, but is also inherently partly chaotic. The goal for the REer is then to find the right amount of structure for the project. This must be done in parallel with considerations for the level of agility of the development process as a whole. Maiden *et al.* [1], suggest that the increasing importance of the Agile paradigm is seen as a driver for creativity. This is due to Agile's emphasis on collaboration, parallel work and shortened iteration cycles. Agility, structure and performance-oriented creativity seem to be strongly related.

Sawyer noted that "*group creative performance could be viewed as the creative process in microcosm"* and concluded that "*observation of group creativity could provide valuable insights into creative fields in which the creative process takes too long to observe directly"* [15]. This is another argument for further research into group performance creativity.

Interactions: Culture, as well as skills, influence the number of performance-oriented moments during RE projects. Performance-related moments are likely to require more openness and more experience, both of which are cultural factors. Performance moments like effective workshops can save time, but are likely to cost more money.

RA11: Explore the amount of structure needed to support creativity on a project.
RA12: Explore the relationship between agile processes and creativity in RE.
RA13: Explore how artistic performance can inform group work in RE.
RA14: Explore how to determine the ideal balance of performance- and product- oriented creativity moments for a specific project.

Problem-Finding and Problem-Solving Orientation. Another dimension identified by Sawyer is the difference between *problem-finding* and *problem-solving* creativity. Problem-finding is an emergent and divergent form of creativity. Problem-solving is a well planned and convergent form of creativity, that aims to lead from a known problem to a solution. For example, an abstract painter who does not know what a painting will look like until it is completed is engaged in a problem-finding activity. In contrast, a painter who faithfully reproduces a photograph is engaged in problem-solving. The two are likely to work in a fundamentally different way. Sawyer explains that in most creative genres, *"the creative process is a constant balance between finding a problem and solving that problem, and then finding a new problem during the solving of the last one"* [5].

Visser suggests that RE requires both problem understanding and problem solving [47]. There is, however, less consensus on whether RE follows a constant movement between problem-finding and problem-solving, or a more CPS-like process where problem-finding and problem-solving are sequential steps. Maiden *et al.* [1] explicitly compare RE to CPS, while Nguyen *et al.* suggest that RE processes involve oscillations of complexity, described by the "catastrophe-cycle model" [48]. They showed how the intertwining of problem understanding and solving is reflected in the incremental structuring and occasional restructuring of the requirements model during the requirements process. Meanwhile, Jones *et al.* [16] have been experimenting with divergent and convergent creativity techniques during requirements workshops. Maiden *et al.* [1] have argued that problem finding in RE was extensively supported by goal-oriented approaches. Authors agree that creativity in RE should be supported by rational and structured processes as well as by emergent and more chaotic processes, and by more collaboration-centric processes [1], [6].

Interactions: Whether a company favours emergence or structured processes is likely to strongly depend on its culture. Emerging processes may seem to involve more risk. Risk, in turn, has an impact on project resources. Safety-critical application domains, for example, are likely to be reluctant to take risks during their creativity process.

RA15: Explore how to support problem solving and problem finding creativity in RE.
RA16: Explore how to define the right interactions between problem finding and problem solving on a specific project.

7 Using the Framework

To make things more concrete, we provide below an example of how the framework could be used to engineer creativity support on a project.

BankMessages is a company that offers messaging services to banks. It establishes messaging standards so that banks can communicate with each other. Recently the company has committed a small multidisciplinary team (16 highly skilled, experienced people) to develop a new product, supposed to enhance the service to a level that is above what clients expect. Figure 2 summarizes the creativity analysis that one could do for their case. On the left column are the contextual factors, as well as the main goals for being creative on the project. On the right, one can see the

corresponding discussion for each dimension of creativity. The lines in the middle (better seen in color) give an idea of the complex interactions that link contextual factors and creativity dimensions. This one-hour work made with, and validated by, key stakeholders helps us decide about the support we need to give to this specific creativity. In this example, one might want to support creativity with an agile development method, including numerous workshops with clients to discover and validate requirements (e.g. through prototyping) and maybe some specific creativity techniques.

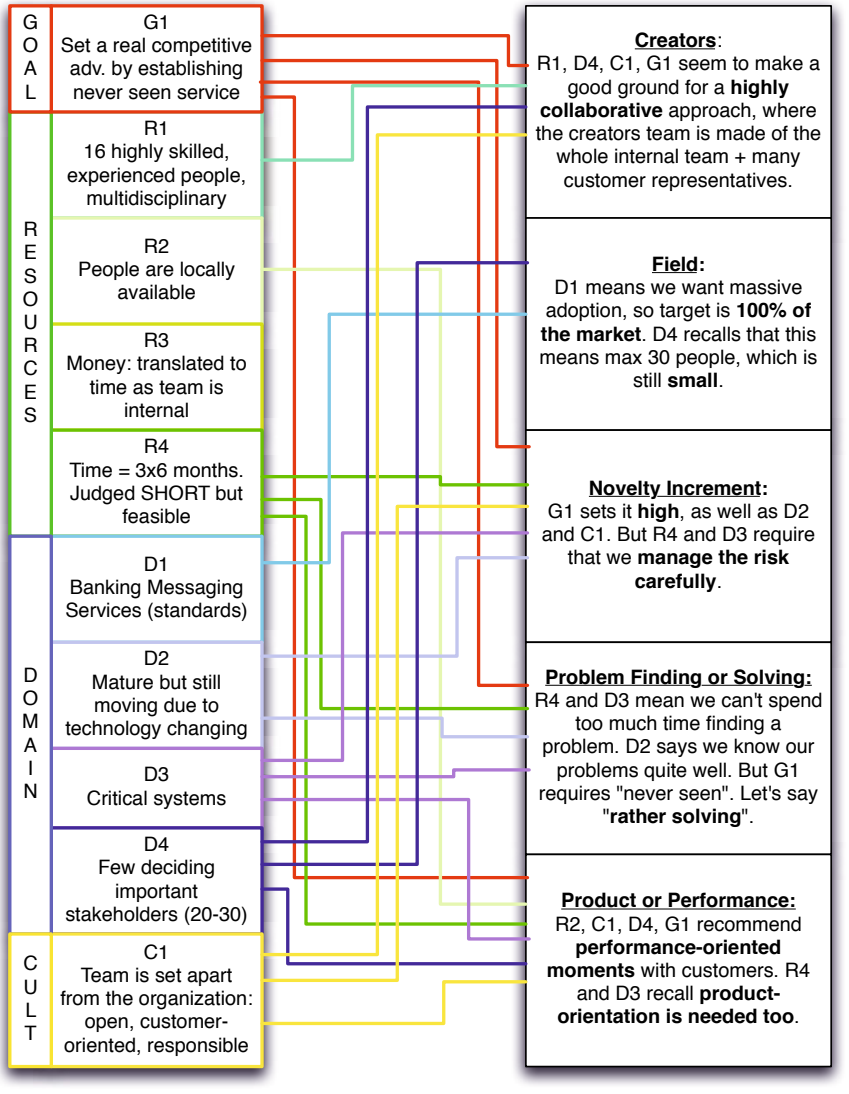

Fig. 2. BankMessage creativity analysis

8 Discussion

Partial Analysis and Validation. During the literature review, the identification of the contextual factors and dimensions was based on the authors' analytical sense. This work would probably benefit from a more systematic way of deriving a framework, and empirical validation would be useful in strengthening the framework. Moreover, as suggested earlier, creativity is a relatively immature topic in RE. Other research disciplines are more mature in their study of creativity, but include a great many references, that are only partially covered by this analysis. This study therefore presents an initial framework proposal, which may not be complete. There may be more contextual factors and dimensions, which it is hoped will be uncovered as this work continues beyond that reported here.

Innovation versus Creativity. Innovation and creativity are two overlapping concepts. The boudary between both is not very clear. A common view is that creativity is about having ideas, and innovation is about making them real, in particular selling them. The definitions of creativity that we have used through this work reject this interpretation, as elaboration is part of creativity. While the term "innovation" is frequently used in management sciences, social sciences almost do not use it; the prefer the term "creativity". Our study focused on this latter body of work, and might benefit from a deeper investigation of the innovation literature.

Creativity in RE versus in Systems Engineering. In this study, we focused on RE. However, as we have shown, the modern understanding of creativity blurs the boundary between an idea and its execution, and shows how both are really part of the creative process. In this context, the RE effort cannot be considered in isolation from the rest of the development. Hence, a natural next step for this work would be to study how far its results can be applied in the broader context of software and systems engineering rather than RE. Studying creativity in agile teams, for example, would be a good candidate in this direction.

9 Conclusion

RE strives to create a new (version of a) system that brings *value*. Creativity is therefore by definition needed on 100% of RE projects. However, it is not always the same type of creativity that is required. Consequently, the first step in providing adequate support for creativity is defining which creativity has to be supported. This study lays the foundations of a method that will eventually guide practitioners in determining their situation-specific creativity needs and choosing adequate support. In this paper, this endeavour was started by studying the creativity literature in Social Sciences and RE, and by confronting them. Three contextual factors and five dimensions of creativity were identified and discussed. These can readily be used by a practitioner to structure the analysis of the creativity needed on a project, for example by asking how each contextual factor interacts with each dimension. The reasoning can flow in both directions: from a given context to dimensions, or from given dimensions to context. This study also highlights that a significant amount of research is needed in exploring, comparing and

combining the various creativity situations uncovered, in order to help the practitioner answer these complex questions and choose an adequate support accordingly.

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