INTERNATIONAL DESIGN CONFERENCE - DESIGN 2004
Dubrovnik, May 18 - 21, 2004.

DESIGN 2004

THE PRINCIPLE OF DIRECTED RADICALITY: TOWARDS A LOGIC OF RADICAL INNOVATION

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Keywords: intelligent focusing, logic of innovation, methodology of radical innovation, directed radicality

1. Introduction

Project RID is a collaborative project in which four Finnish companies are aiming to build innovation cultures that will be capable to produce radical (or breakthrough) innovations. Our Institute of Machine Design is supporting these companies in this very pragmatic, non-academic challenge.
During the last three years, we have reviewed many studies that have considered different aspects of radical innovation. However they have provided us a very limited amount of information concerning its methodology. This paper presents some central ideas and insights that I personally have found interesting during my working with issues of radical innovation methodology.
The main purpose of this paper is to stimulate and support the methodological R&D of radical innovation. It consists of three complementary parts: (1) a review of Gerald Smith's logic of innovation and a proposal of its extension into the study of radical innovation; (2) a presentation of a conceptual hierarchy that helps to differentiate between multiple methodological constructs of radical innovation; and (3) a demonstration of the power of directed radicality in the context of the paradigmatic Nine Dots puzzle that is said to require the "out-of-the-box" thinking. I hope that this paper will stimulate a more intensive activity in these important and difficult methodological issues of radical innovation.

2. Towards the logic of radical innovation

Smith's chapter "Towards a logic of innovation" in the new International Handbook of Innovation [Smith 2003] provides a good conceptual background for this shorter paper. Smith refers with the term 'logic' to "any consciously controlled mental activities that enhance one's prospects for generating valuable ideas." Because he is considering innovation in general (and more specifically, generation of creative ideas or idea-generation), we can presuppose that his 'logic of innovation' should provide a basis for investigating some fundamental questions about the methodology of radical innovation.

2.1 Smith's logic of innovation: Some of its details and conclusions

I recommend you to read Smith's paper in its totality. After this reading, it is easier follow and assess my reasoning that is focusing on seeking out a 'logic' in the domain of radical innovation and its methodology.
What is Smith's notion of innovation logic? Table 1 contains some of his characterizations of it. A common denominator in these characterizations seems to be the notion of conscious control. Table 2 contains more characterizations about the nature of this control.

Table 1. Characterizations for an innovation logic [Smith 2003; boldfaces added]

In this paper I consider whether innovation exhibits or can be equipped with a 'logic', that term being construed broadly to compass any **consciously controlled** mental activities that enhance one's prospects for generating valuable ideas. Such logic would lie in the considerable space between inspiration and perspiration, providing mental **tools that innovators can deploy in their search** for solutions. (p 347)
Where would one look to find a logic of innovation, **consciously deployable means** of generating innovative ideas? (p 353)
Creativity or idea-generation methods might be regarded as existence proofs of the logic of innovation. They are, after all, mental **tools that people use** to generate innovative ideas. (p 359)
Not surprisingly, then, creativity techniques embody effective idea-generation devices, and their prescribed mental behaviors are ones that successful innovators often employ on their own. Some devices fall short on the **operationality requirement for innovation logic**: their performance is not sufficiently subject to **conscious control**. (p 360)

Table 2. Characterizations of the nature of control [Smith 2003; boldfaces added]

The perspiration account, however, fails to explain how people generate insightful, non-obvious possibilities that result in major innovative breakthroughs. Thus, the poetic qualities that make Edison's epigram ['1% inspiration and 99% perspiration] memorable also makes it misleading. Recognizing the most divergent aspects of innovative throught, it overlooks elements that are more central, notably the **importance of domain knowledge and intelligent deliberation**. **Reliance on knowledge and reflective thought** were the hallmarks of Edison's own approach to innovation... (p 347)
Innovators are encouraged to challenge assumptions and to look at things from different perspectives. Advice of this kind prompts one to question dominant ways of thinking in a field, **to think about its content**. The recommendation to think more abstractly about the innovation task aims at **inducing a deeper understanding of the problem**, one that **grasps its fundamental nature**. (p 361)
The most substantial part of this logic consists of activities, mostly mental, that are infused with or devised in light of **knowledge about innovation tasks and the world**. Innovators are advised to think about certain things in certain ways because these ways of thinking are **consonant with reality**; they **reflect and exploit its underlying structure**. (p 361)
Rather than being an abstract formal or purely psychological procedure, the logic of innovation is **infused with content**. Recommended thinking practices embody **knowledge of innovation tasks and the nature of reality**. In this respect, innovation logic conforms to the psychological dictum that behavior is an **adaptation to reality**. ...innovation logic **exploits environmental 'affordances'**; it uses **opportunities provided by the idea-generation task**. Many opportunities derive from the **underlying structure of reality, its regularities**, expressed in principles of widespread applicability. (p 361)
Effective thinking practices of whatever kind...are effective by virtue of **being adapted to the realities they address**, as a result of **being informed by knowledge of those realities**. (pp 361-362)
This chapter has demonstrated that the process of generating innovative ideas can be ***directed intelligently***. Though unbridled imagination has a role, the idea-generation process can benefit significantly from **deliberate, reflective thought that uses knowledge** to achieve its goals. As support for this conclusion, the chapter identified elements of the logic of innovation, pieces of declarative and procedural knowledge that promote idea generation. (p 360)
This logic is **heuristic**, not formal. No strong idea-generation procedures have been uncovered. Rather, innovation logic encompasses a **variety of informal methods, strategies, and pieces of advice**. (p 360)
The way – logic of innovation – uses consciously **controlled mental activities informed by content knowledge** to generate promising ideas and alternatives. (p 362)

In summary, Smith's logic of innovation consists of a collection of knowledge-based devices that help an innovator to control intelligently his search of solutions. I wanted to underline the fact that this

collection contains a central part of Altshuller's 'primary and objective side of creativity' (noted explicitly by Smith).
I personally consider Smith's failure to apply Newell's knowledge-level approach as the greatest weakness of his study [cf. Newell 1990, Dasgupta 1994]. In a knowledge-level analysis, we don't need any references to attributes like 'mental,' 'psychological' and 'purely psychological.' Moreover, a knowledge-level analysis helps to see the tight connectedness between knowledge and intelligent behavior. In other words, when we are analyzing 'logics' of design, optimization (or operations research), mathematical problem-solving, logical reasoning, and so on, we don't need references to any mental (psychological) characteristics. Therefore, when I am studying the core methodological issues of radical innovation, I don't consider any subjective aspects of innovators.
A second weakness of Smith's analysis is its 'fuzzy' use of numerous methodological notions (like mean, practice, tool, devise, method, procedure, technique, framework, principle, pattern, theme, advice, recommendation, template, schema, practical model, strategy, tactic, heuristic, algorithm, and some other). This same weakness is characteristical in many methodological studies of design.

2.2 Directed radicality as a subtype of innovation logic

I refer with the notion of 'directed radicality' to "any opportunity to intelligently control the generation of new concepts." It proposes to transfer Smith's central message into the domain of radical innovation. In other words, I accept tentatively Smith's general argumentation and propose to apply it in the R&D of radical innovation methodology. Smith does not make any reservations in respect to the domain of its applicability. Therefore we may assume that Smith's logic of innovation must be extended into the study of radical innovation methodology. And the domain of radical innovation, in turn, should provide a strong context for the validity testing of Smith's generic logic of innovation.

3. Methodological contructs of radical innovation: a conceptual hierarchy

3.1 A generic framework

I use a five-level conceptual hierarchy of methodological constructs (Fig. 1). Paradigms are on its top. They present the basic orientations. Principles specify the foundational aspects of paradigms. Methods (methodologies) instantiate principles in the specific systematic ways of doing something that belongs to their domain. Specific practices in turn implement operationally methods. On the bottom of this hierarchy, we find tools (like computer programs) that can be used to implement specific practices.

Figure 1. A generic hierarchy of methodological constructs

This hierarchy is not the only possible way to represent and relate different methodological constructs. I confess its ambiquities, but it seems to be 'just enough' for my present purpose.

3.2 Its application to radical innovation methodology

Table 3 presents a general view of my characterization of radical innovation methodologies. It provides a rather simplicistic description of this methodology. I hope that it provides a starting point for methodological dialogues and debates – it is not intended to be a final word in any sense.

Table 3. Methodological constructs of radical innovation

Generic Category	*Methodological Construct of Radical Innovation*
Paradigm	Proactive innovation and renewal (or Proactive excelling)
Principle	Directed radicality
Method	I-TRIZ / Directed Evolution
Practice	Pattern of Increasing Dynamicity and Controllablility
Tool	Shpakovsky et al.'s Concept Generator

Paradigms: I propose Proactive innovation and renewal (or Proactive excelling) as the fundamental methodological paradigm of radical innovation. It contains the core assumption that radical innovations can be designed proactively. Excelling refers here to "doing something better than any corresponding existing solution in a domain." It contains a basic orientation that in the practical contexts it is nearly always possible to find opportunities to make something better" [cf. Greene 2001]. Of course, the best is an enemy of excelling: If the best solution is already found, we cannot find opportunities for innovation. It were a stupidity to seek out a new solution for finding the roots of a quadratic equation $ax^2 + bx + c = 0$. But the practical business situations are not 'saturated' with this kind of best solutions, and therefore we can proactively search out new excelling solutions with significant value adds.

Principles: Principle of directed radicality presents the idea that there are numerous specific ways to guide the seach of new, excelling solution concepts. Every expert innovator (inventor) has numerous specific ways to directed his creative work by intelligent focusing. Specific creativity approaches like 'directed creativity' are explicitly referring to the application of this principle.

Methodologies: Altshuller's TRIZ or Theory of Inventive Problem Solving has been proposed by many authors of conceptual design as a promising methodology of concept generation [eg., Mello 2002]. Hovever, it seems to be true that the traditional TRIZ techniques are better considered as methods of incremental innovation (or improvement) than methods of radical innovation.

But the progress of TRIZ thinking contains some important keys to true new concept generation. Especially its Patterns of Evolution provide many fruitful opportunities for intelligent focusing during concept generation. Boris Zlotin and Alla Zusman's Directed Evolution (DE) is a very promising methodology for radical innovation [Zlotin & Zusman 2001a, 2001b].

Practices: DE thinking applies the traditional TRIZ ideas about the use of many developmental laws of technical systems. Altshuller's *40 Principles* [Altshuller 1998, Salamatov 1999] describes some of them and their application. Inside the TRIZ community, it seems to be some confusion in respect to the methodological status of these laws of evolution. In any case, the basic point from the perspective of intelligent focusing (or directed radicality in the context of radical innovation) is the possibility of knowledge-intensive directed creativity by applying them effectively independent of their theoretical status.

My personal favourite subset of these "operational principles" is:

- Segmentation (S)
- Dynamicity (D), and
- Changes of Parameters (C).

By combining them into an integrated operator, we get a SDC Operator. This construct provides a structured and well-warranted approach to any invention task.

It is important to notice that 'Increased Dynamicity and Controllability' has used in TRIZ thinking in two different contexts. Originally, it was included in Alshuller's list of 40 principles as its method No. 15. The inventors of DE methodology have considered it as a central Pattern of Evolution among nine other patterns. However, from the perspective of intelligent focusing both these ways of thinking provide fruitful opportunities for generating radically new concepts.

Tools: Many TRIZ specialists and companies have developed many software tools for inventive thinking. Most of them support incremental innovation rather than true radical innovation in the sense of new concept generation. However Shpakovsky and others' [Shpakovsky et al. 2003] Concept Generator is a promising tool for radical innovation. It can be considered as a tool that implements the

paradigm of Proactive Excelling by applying the Principle of Directed Radicality and Directed Evolution methodology through the use of Increased Dynamicity and Controllability practice (and some other laws and lines of evolution).

4. Radically new solutions for the Nine Dots puzzle: a demonstration

The Nine Dots puzzle (or Nine Dots problem) has presented in many contexts as a paradigmatic example of a puzzle (problem) that requires an out-of-the-box thinking [eg., Adams 1974, Mello 2002]. James L. Adams presents several kinds of solution to this puzzle, but he does not provide to his readers any systematic task analysis for the complete deep understanding of this task and its solution opportunities. Some other authors have presented this puzzle as a paradigmatic example of problems that have only one right solution. (It is a little ironical that one of them is aimed to provide *A Futures-Oriented Course in Inventive Problem Solving* [Thomas 1981].)
In general, most thinking around this puzzle has done inside the "box of Gestalt psychology": Its students have supposed that the only right way to solve it is to get an insight that breaks a Gestalt fixation. This fixation means that problem solvers are imprisoned inside the box formed by the nine dots that are given in the description of task demands.

Figure 2(a) presents the starting state, and the instruction of this task is: "Connect the nine dots using only four straight lines, without taking your pen off the paper." Note that this task description contains all the explicitly given task demands. As a real puzzle, the subjects may add their own 'task requirements' that do its solving much more complex and restricted than what is originally required. (This is a definitional characteristic of a puzzle.)

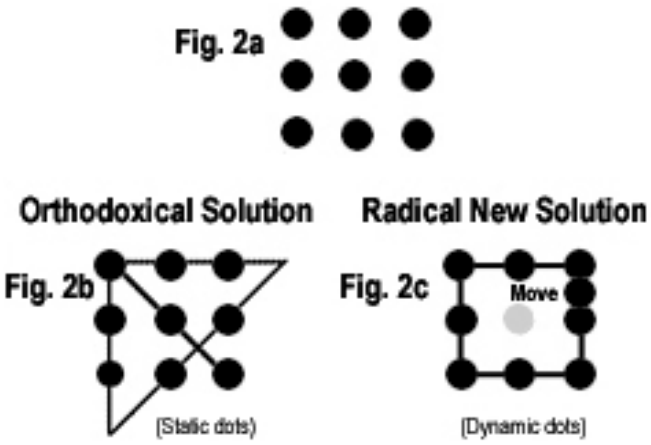

Figure 2. The Nine Dots puzzle and its solutions

Figure 2(b) describes the 'orthodoxical' solution that is generally presented as the 'only and right' solution. (One innovation company has used it as its logo.) Its message has been that in order to solve this puzzle, you need to step out of the box that is determined by the periphery of the square dot pattern. It has been thought that it is impossible to solve this problem without "stepping out of the box".
I have never met in the Nine Dots literature the simplest solution presented in Figure 2(c). You can recognize very easily an opportunity to apply successfully the principle of dynamicity. You need only change your self-imposed assumption of the static, inmovable nature of dots and move the 'central dot' on the periphery before the drawing of four lines. Do you accept this solution? If not, please, check carefully your reasoning.
Some authors have presented solutions that change the relative positions of dots by folding the paper. In reality, these solutions are also using the principle of increased dynamicity and controllability. My own proposal for proceeding on this basis is to clip the paper into separate dots, rearrange them on some arbitrarily formed structure of four connected lines and then draw the reguired four lines for

connecting dots. In other words, there are many alternative ways to apply this principle of invention. My solution is the simpliest and most dynamic one – the most inventive one. In reality, we can find an infinite set of right solutions, because you have an opportunity to draw arbitrarily any four lines and locate the nine dots atribtrarily on them. The solution presented in Figure 2(c) is only one of them. I personally prefer this specific solution, because it allows to apply the most subjects' first trial (i.e., four lines on the square's periphery) as its basis and it is also a time-efficient way of solving this puzzle as a concrete drawing task.

I know many dot puzzles that ask us explicitly to move some dots in order to find the required solution. Why do we not recognize this opportunity in the context of Nine Dots puzzle? In any case, the systematic use of appropriate DE practices will provide effective ways of directed radicality.

5. In conclusion

It is a danger that we 'reinvent the wheel' in the development of radical innovation methodologies. Therefore we need a proven framework that locates the conceptual places of different methodological constructs and focuses our attention on the core issues of directed focusing in idea generation. Directed Evolution seems to provide us a promising approach to study these issues for the purpose of radical innovation development.

Acknowledgement

National Technology Agency of Finland (TEKES) is funding the participation of the Institute of Machine Design (Tampere University of Technology) in Project RID.

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