Innovation: The Living Laboratory Perspective

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ABSTRACT

Innovation research is highly interdisciplinary and has attracted numerous science and practice communities. Though innovation results are broadly applicable, this paper focuses on engineering and service domains. The two are tightly interrelated, as the benefits of product innovation are realized through the business activities, and certain business undertakings may impact the product design innovation. A requirements-driven approach to innovation is proposed. It is a natural extension of the system of customer requirements in terms of their number and type and the expanded ways of collecting and processing them. The proposed approach is implemented as the Living Innovation Laboratory.

Keywords: Innovation, requirements-driven innovation, data-driven innovation.

1. INTRODUCTION

Innovation is considered as one of the most important factors enabling organizations to effectively compete [10]. In fact, some economists view innovation as the primary source of success in the global market [55]. Due to its importance and potential benefits, the need to understand innovation has resulted in renewed interest among research and corporate communities.

Though numerous innovation studies have been published, the literature on innovation is filled with myths as well as partial and inconclusive research findings. Innovation is often discussed based on experiences specific to a particular case study. Most noted examples include companies such as 3M and Apple Computer have been broadly studied in the literature. The goal of these efforts is to develop a better understanding of innovation from the corporations leading in innovation. Practitioners, however, doubt that these findings would produce similar results in their corporations. Pfeffer and Sutton [47] presented a compelling example of companies failing to emulate the well-known performance-ranking system implemented at General Electric.

Some companies have followed conventional thinking for too long ([18]. For example, Microsoft's reluctance to embrace the concept of open-source software; Polaroid's slow progress on digital cameras; GM's and Ford's lack of enthusiasm for hybrid cars, improvements in fuel economy, and failure to embrace the common platform concept; and media companies overlooking blogs.

Imagine that the science of innovation [34] was available, and that any corporation could make rational decisions using it. Science-based innovation would certainly compete well with decisions made by conventional and unconventional approaches. Innovation science, however, does not exist yet, despite extensive studies. Some may even argue that there is no science in innovation endeavors. Regardless of whether one supports or opposes the concept of innovation science, there seems to be no doubt that innovation is a process and there must be some core elements common to many innovation scenarios and cases discussed in the literature. The way these common elements are selected, arranged, and generalized may determine the progress in innovation.

The concepts presented in this paper apply to innovation products, systems, processes, and services. The term artifact will be used to denote all four objects of innovation; however, the individual terms may be occasionally used as well.

The paper is organized as follows. The literature pertinent to the topic discussed in the paper is reviewed in Section 2. The proposed concept of requirements-driven innovation is discussed in Section 3 and implemented using the framework of the Living Innovation Laboratory outlined in Section 4. Section 5 concludes the paper.

2. LITERATURE REVIEW

Innovation has attracted the attention of various disciplines. The most noticeable include product life-cycle (PLC) management, technology management, and organizational learning and competition [36]. The scope of research ranges from studying tangible artifacts (e.g., products) and abstract flow processes (e.g., innovation process), to initializing innovation undertakings (e.g., R&D), end-performance measurements (e.g., patents), interactions within functional departments (e.g., marketing) and the external corporate environment (cross industries).

Widely-cited research results include Foster's "S-curve" theory, Utterback's dynamic innovation process, Kline and Rosenberg's chain link model, Schumpeter's view on economic development, and Kleinschmidt and Cooper's market and technological newness map ([15], [29], [55], [61]). Numerous researchers have reported on empirical studies—some of which support and other oppose the previously published results—as well as created methodologies and hypotheses pertinent to innovation. For such a widely studied research topic, one would expect a unified understanding of innovation, including a clear comparison of competing theories and models. However, each research community has approached innovation from its own perspective, using different terminology, varying scope, and different descriptions of processes. In an effort to measure the novelty of innovation, Garcia and Calentone [17] pointed to at least 15 constructs and 51 distinct scale items used in 21 empirical studies of innovation in new product development (NPD). The authors concluded that much of the published innovation research reiterates, re-labels, or redefines what has been discussed in the literature. The authors proposed an operational framework based on macro/micro and technology/market discontinuities, and they categorized innovation as "radical," "really new" and "incremental." Sood and Tellis [56] criticized the use of such terms as "radical," "revolutionary," "disruptive," "discontinuous," or "breakthrough" as problematic because they describe the result of innovation instead of focusing on its characteristics. Sood and Tellis [56] defined three types of innovation: "platform," "component," and "design," to emphasize the technological breakthrough, material selection, configuration and layout within the system. However, it is clear that researchers do not agree on the fundamental issue of how to innovate and measure the level of innovation.

Though the breadth of innovation studies contributes to the wealth of information, it also complicates practical use of the research results. Gopalakrishnan and Damanpour [21] examined the economic, sociologic, and technological views of innovation in three dimensions: innovation process stage, analysis level, and innovation type. Montalvo [41] argued that one shortcoming of the current literature was in over-emphasizing the individual determinants. Becheikh *et al.* [5] reviewed the technology innovation literature from the early 1990s to the early 2000s, focusing on manufacturing. These studies, though containing a number of specific insights, cause one to question how to integrate and interpret them. If the scope of innovation research becomes too limited, then much future research could be a mere "re-discovery" of the past results.

The requirements-driven approach to innovation discussed in this paper is applicable to products and processes in most industrial and service corporations. As long as the success of innovation is judged by the customers, the central concept of capturing requirements in the development process and innovation is universal.

2.1 Definition of Innovation

Innovation has numerous definitions; however, employing one that is universally accepted is important. For example, some researchers use the term "technology-based innovation" or "technological innovation" to represent the general concept of innovation. Others associate innovation with a certain degree of technological breakthrough, which leads one to question whether technological innovation is different from non-technological innovation. If so, what is the normative measure used to distinguish them? If technology is indeed defined in the context of innovation, is the term technological innovation redundant or possibly misleading?

Schumpeter's [55] early research on innovation pointed to the following five characteristics: new goods, new processes, new markets, new sources of supply of new materials, and a new organizational status ([39], [55]). Innovation is defined as an iterative process initiated by the perception of a new market and/or new service opportunity for a technology based invention which lead to the development, production, and marketing, all aiming at the commercial success of the invention. Galanakis [16] proposed a much broader definition of innovation: "the creation of new products, processes, knowledge or services by using new or existing scientific or technological knowledge, which provides a degree of novelty either to the developer, the industrial sector, the nation or the world, to succeed in the market place." An immediate observation from these definitions is the prominent presence of technology. Many researchers agree that innovation involves technological development or a breakthrough that is superior to existing developments ([24], [38], [68]). The new technology may include a new mechanism or device, but most importantly, it involves the creation of new knowledge ([7], [14]). Another important issue is that innovation has to create some value ([27], [42], [45]), and this value should be manifested by its acceptance in an existing market or the emergence of a new market. Thus, commercialization success is a major determinant of innovation ([16], [19], [53]).

2.2 Innovation Level

The study of the level of innovation, also called the "novelty of innovation," "degree of innovation," "newness of innovation," or "innovativeness" has attracted research attention. Researchers differ not only on definitions, but also on the attributes and the impact of innovation ([6], [40]).

The term incremental innovation is often used by researchers to describe an iterative process that improves or extends functionality of the existing products. Other terms in the literature that imply a similar idea include "improving" [37] and "continuum" [57]. Incremental innovation often follows a more systematic development process. The process could begin with an idea generated in an R&D (Research and Development) project, or provided by marketing for the existing products to better meet the customer needs. Although technological advancements in an incremental innovation could be enormous, they do not necessarily open up a new market, as the customers may not fully appreciate the value of the functional enhancements offered. Incremental innovation is the core of daily business activities [17]. To satisfy customers' needs, companies constantly use R&D resources to extend the functionality of existing products or create product families. To increase customer satisfaction, companies offer 24/7 customer service and online systems for managing transactions. Many researchers believe that most corporations today can initiate and handle incremental innovation. While this view may hold, it is worth mentioning that the difference between being a winner and a loser in today's competitive market has much to do with the speed at which ideas are generated, refined, prototyped, and implemented.

Another widely studied topic is radical innovation and its specific terms, which include "discontinuous," "disruptive," "landmarking," and "groundbreaking." Radical innovation is often depicted as involving a fundamental technological breakthrough or causing drastic changes in the market place ([21], [64]). For example, flying was not a viable means of transportation before an airplane was created. In contrast, portable music-playing devices were not uncommon before the launch of Apple iPod; however, factors such as the iPod's intriguing design, multifunctional capability, and successful bundling with iTunes — the online music store exclusively for iPod owners — contributed to its overall success. It is also said that radical innovation constitutes only about 10% of all innovations ([49], [52]), and therefore it cannot be addressed by the routine corporate management practices structured for common product improvement [3]. The uncertainty of radical innovation entails unique challenges for management. Projects involving radical innovation at well-established corporations are inherently highly technologically-driven, changing the roles and functions of non-R&D departments [64].

It is not known what entity or person has the most impact on the attribute "discontinuous." Potential candidates are R&D staff, customers, or the entire industry. In most cases, innovation is evolutionary; knowledge accumulation is a combination of diverse sources, and while innovation may not be seen as radical to the firm, it could be perceived as radical by customers ([22], [40], [50]). Using the very definition of innovation, most researchers agree that at least two quadrants play a significant role in radical innovation, namely, technology and market forces ([17], [42], [63]).

2.3 Product, Process, and Business Innovation

Product innovation is concerned with the introduction of new goods that differ from the ones existing in the market. Process innovation is the creation and modification of methods to improve the existing process (including the business process). The direct sales model introduced by the Dell Corporation is a clear example of process innovation that has become the company's core strength. It began with an attempt to eliminate the lengthy and costly selling process, which impacted the total product price. While many computer manufacturers concentrated on enterprise integration, Dell decided to outsource many non-competitive tasks. Buying experience, affordable pricing, and excellent customer support have satisfied the customer needs, and the PC business has been changed.

From a requirements-driven standpoint, the idea of product innovation can often be traced back to the deficiency of certain product functions. If the product design is modular, it is much easier for a company to improve or redesign its functions. The innovation produced from mapping product functions into customer requirements is generally incremental. Higher level innovation often addresses customer requirements other than function and form.

Besides innovation by incorporating new functions, e.g., a copy machine plus digitizer plus fax plus email, other approaches are possible:

- Incorporating inventions into existing artifacts
- Integrating inventions
- Extending inventions
- Impacting the environment, e.g., marketing.

2.4 Innovation Life-cycle and Drivers

The traditional view of the innovation process is based on the technology-push approach — a linear model emphasizing the advancements in science and technology as a sole event triggering the creation of a new artifact. The process is initiated by a technological breakthrough and followed by a series of developments. This view was criticized by researchers as neglecting the influence of customers. A market-pull theory, sometimes referred to as the chain-link model [31], was proposed to stress market demands and customer requirements [28]. Both views are seen as inadequate in capturing the essence of innovation, neglecting its evolutionary nature, and the fact that it integrates diverse knowledge sources [46]. The consensus among researchers is that the innovation process is dynamic, nonlinear, and complex [16]. Novel ideas have to prove beneficial to customers [67]. Intra-organizational functionalities and external relations with various entities enhance the innovation process. Von Hippel and von Krogh [66] discussed a largely controversial issue of the benefits to society and innovators from freely revealing inventions.

Utterback and Abernathy's [62] research on the life-cycle of product and process innovation offered another insight into innovation. At the early stage, exploratory ideas about product design are generated through scientific or engineering investigations. They are further refined by collaborative inputs from cross-functional departments. The initial design of a new product in numerous variants is undertaken to meet the customer's needs. Through competition and adaptation, a predominant design prevails over less popular designs. Once the predominant design emerges, an awareness of the process of innovation is strengthened. As the customer base stabilizes, a company concentrates on a cost-saving strategy. Product and process innovation subsequently reaches its peak and diminishes with the maturity of the product. This view has been criticized by some researchers arguing that product and process innovations do not necessarily follow a sequential pattern. Demand plays an important role in guiding the product and process innovation activities. In other words, the dynamics of demand is the cause of innovation, and not a dependent phenomenon ([1], [2]).

Researchers investigating critical drivers of the innovation process agree that R&D is the most important driving force within any organization. The intensity of R&D activities directly impacts how innovation is generated, formed, and altered [30], [69]). Certain issues concerning R&D activities have attracted research attention [16]. Many researchers have examined the relationship between the size of a firm and its R&D performance. A number have concluded that a larger firm with more R&D resources is more likely to be innovative, as it can fund many trial-and-error experiments [12]. Others have found that the structure and bureaucracy of larger firms have prohibited R&D staff from being innovative [58]. Small companies appear to be more flexible in generating innovations; however, in some cases, mixed results have been reported [39].

Marketing input is another important factor that is often mentioned in addition to R&D. Marketing detects market trends, competitors' movements, and customer needs. Whether the innovative idea is incremental or discontinuous, the capability to match developing technology or to assess the value of an added function is essential. The role of marketing may be different in an incremental or discontinuous innovation process, but it is equally important [4]. An integrated enterprise, having the ability to absorb heterogeneous information and transform it into a practical implementation plan, is, according to many researchers, the best environment for innovation ([6], [8], [39], 50]). Gerwin [20] proposed a "process manager" who oversees the financial, technical, and social functions which impact the innovation process.

Companies use various means to reach out to customers to incorporate their needs into the product development process. Many researchers have indicated that companies use an incorrect approach and incorrect measurements when consulting with customers. Ulwick [60] pointed out that companies should not expect solutions to be offered by potential customers; rather, they should ask them about the desired product's characteristics. He argued that customers may only know what they have experienced and may have a limited frame of reference when suggesting innovative ideas. In addition, companies that link their products too closely to their customers may end up creating incremental innovation. Veryzer [64] emphasized the need for caution with customer input, and pointed out the importance of discontinuous product development, e.g., the customer's input should be introduced later in the project. Christensen [10] stated that customers may emphasize the product's functionality to too great a degree. For example, many customers buy milkshakes based on the drink's thickness and strong flavor. The milkshake is thus competing with the "functionality" of such complementary products as sandwiches, soft drinks, and salads. Without understanding this phenomenon, fast food companies may develop a product that is completely at odds with what the customers actually want.

3. REQUIREMENTS-DRIVEN INNOVATION

3.1. The Need for Requirements-driven Innovation

Recognizing customer requirements as derived from product and service has been widely practiced by successful corporations. Traditionally, requirements have been managed by marketing departments. Conventional marketing techniques such as questionnaires, focus groups or interviews are widely used. In the digital world, customer opinions are recorded on blogs, social network forums, and other digital media. Using digital media to generate useful information about customer requirements is of paramount importance. Google's business model is based on matching advertisements with targeted audiences. More recent social network internet sites, such as MySpace or YouTube, follow Google's model by sending the right information to the right people. The exiting and emerging internet models can be used in the proposed Living Innovation Laboratory (see Section 4). Data-mining algorithms can be applied to process unstructured data to generate knowledge about customers [33].

3.2 Expanded Categories of Requirements

The customer perspective has been behind the creation and processes in the last two decades. This market focus has generally been reflected in the product's functions and form. Other commonly used attributes to attract customers and at the same time improve business performance have been quality, reliability, and cost.

The level of innovation I can be expressed as a function of requirements X, $I = F(X)$. Fig. 1 shows an example vector X involving the following classes of requirements:

- Function
- Form
- Surprise
- Culture
- Emotion
- Customer experience

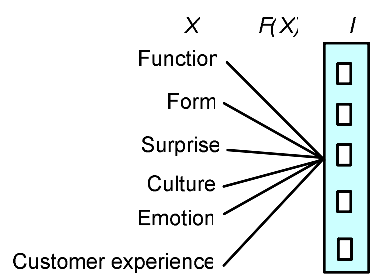

Fig. 1: A tree of expanded requirements.

The list of requirements impacting innovation expands beyond functions and form. In fact, the AND/OR tree representation allowing the inclusion of alternatives may be used to elicit and represent requirements [35]. The approach advocated in this paper calls for broadening the range of requirements over the traditionally considered ones (mostly function and form). Understanding the breadth, content, and structure of the customer requirements is key to innovation. A customer of today purchases a product that meets her/his functional requirements (product personalization), but also seriously considers additional attributes such as surprise (e.g., unexpected product function), pleasure (e.g., driving a car), emotion, customer experience, and so on.

Ultimately the increased level of innovation I has to translate into benefits, e.g., increased market share.

3.3 Sources of Requirements

In the past two decades the design of products and services has been largely driven by customers. After all, the customer buys a product or uses a service. The "customer-as-the-king" model was preceded by the "engineer-as-the-king" (often designer) model, where the technical experts made the decisions for the customer. The customer was expected to accept the offered product or service.

Both models of eliciting requirements have focused on the product and service functions. Product innovation calls for additional requirements, as indicated in Fig. 1, making it worthy of the label "innovative product." The sources of innovation-fostering requirements are much wider and they include:

- Customers. The information from the customers should be collected over the artifact's life-cycle rather than during a limited time frame. Processing that information and blending it with other sources of data and information could be the ultimate key to the success of the designed artifact.
- Domain experts. Though the importance of the "voice-of-the engineer" in forming requirements has been marginalized in the last few decades, it needs to be brought back and expanded when innovating. It is true that a customer is the one who ultimately pays for the product; however, s/he may not be aware of the possibilities that a new technology or a product/process combination may offer. A technologist may generate innovative features of a product.
- Legacy materials. All kinds of standard and digital libraries could be searched in the quest of innovation. The search would involve hypotheses, theories, innovation rules, and information about inventors and innovators. Data-mining algorithms could create previously unseen value in fusing data and information from various sources.
- Artifact life-cycle data. An artifact leaves a data trail over its life cycle. This is in addition to the information provided by the customers or experts before and after the product has entered the market. The volume of data collected can be large, e.g., imagine a database of cockpit and maintenance data collected over the useful life of an airplane. The artifact's lifetime data can deliver valuable knowledge leading to requirements spurring innovation.

People are fascinated with inventions and innovations. In fact progress and development across civilizations have been fueled by human inventiveness. An analysis of certain historical information, e.g., studying inventors or the discovery of commonality among invention processes, could lead to the creation of a body of innovation knowledge (see Fig. 2).

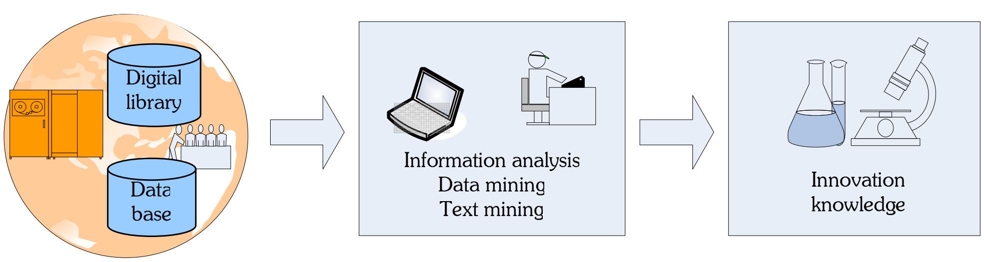

Fig. 2: Discovery of innovation knowledge principles through data and text mining of legacy libraries.

A product creates a data trail at every phase of its life cycle, as illustrated in Fig. 3. Some of the data serves the existing product while other data is stored for future use.

Various analyses could be performed on the data collected over the product's life cycle, including extraction of innovation fostering requirements. The locally extracted requirements could be integrated in an innovation-inspiring list or a tree (see Fig. 3).

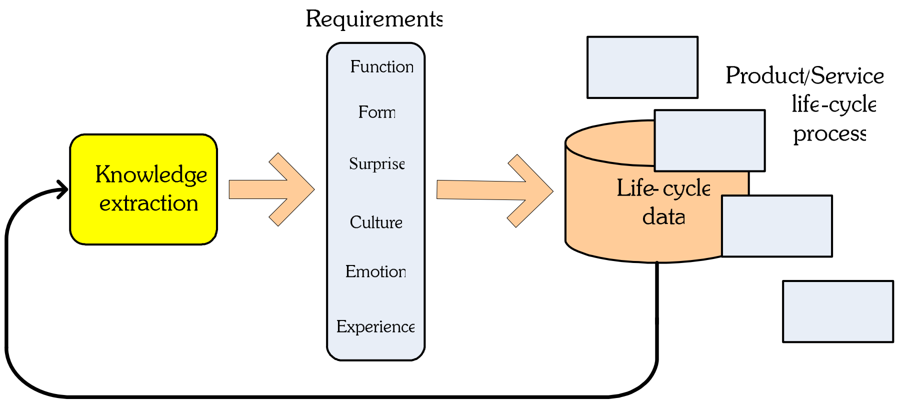

Fig. 3: Extraction of innovation requirements and knowledge from the data collected over the product/service life cycle.

4. THE LIVING INNOVATION LABORATORY

The integration of users and stakeholders into product and service development has been validated in a number of industries. For example, Procter & Gamble has opened its product development processes to key stakeholders, which has improved acceptance of their products. Their innovation success rate has doubled in two years, while the R&D expenditure has decreased by 3.4% [25].

Despite the success with the customer-driven development process Huston and Sakkab [25] have a few words of caution, namely:

- Do not assume that customer-generated ideas can be implemented as originally presented. Additional development is usually needed.
- Do not underestimate the internal resources required.
- The ideas should be supported by the senior management, including the CEO.

Another convincing example of customer-based innovation was discussed in [13]. Clinicians often administer drugs for cases that are not indicated on the label. It is estimated that in areas such as chemotherapy, the off-label use of drugs accounts for as much as 85% of the total prescriptions. To better understand this phenomenon, DeMonaco *et al.* [13] studied new therapeutic uses of 29 newly approved drugs. During a five-year period, after the drugs have been introduced into the market, 143 new applications were identified in a computerized search of the literature. Eighty-two (57%) of the 143 drug therapy innovations in the sample studied were discovered by practicing clinicians through field discovery. Customers' involvement in product design in a broader context is discussed in [65].

The examples cited above indicate that a customer-centered development makes a customer as much a producer as a consumer. Involving customers in the dialogue with producers requires new methodologies, structures, and tools. Various ways of implementing the concept of requirements-driven innovation advocated in this paper can be envisioned. A viable alternative follows the living innovation laboratory concept discussed next.

The concept of a Living Lab emerged in Europe [11] and was adopted here. It was called the Living Innovation Laboratory to stress the interest in fostering innovation. Though the scope of the Living Lab involves all aspects of product/service development, the focus of the Innovation Living Laboratory is innovation. It must be understood, however, that innovation does not happen in isolation, nor is it necessarily the main driver of the product/service development, but it is generally an integral component of all development activities.

A Living Lab allows companies to involve end-users in the development of a new product or a service. Niitamo *et al.* [44] advocated that a Living Lab should offer access to competing technologies delivered through different business models. The Living Lab concept calls for all stakeholders of a product or a service to participate in the development process. It supports innovation of products and services that are validated in collaborative, multi-contextual, empirical real-world environments. The individual focuses on his/her role as a person, user, customer, or worker. The main difference between the traditional consumer research programs and the Living Lab approach is in the multi-role and multi-faceted involvement of the customer. The customers offer innovative ideas, validate the design, and become involved in a dialogue with a producer. This integration of the customer into the development process ensures highly reliable market evaluation, reducing technology development costs and business risks.

The proposed concept of the Living Innovation Laboratory (LIL) is described in the next section. The SADT (Structured Analysis and Design Technique) notation introduced by Ross and Schoman [51] was used to depict the LIL structure (see Fig. 4).

4.1 Structure of the Living Innovation Laboratory

The input to the Living Innovation Laboratory (LIL) constitutes unrefined requirements and the supporting data, information, and knowledge collected from the four sources discussed in Section 3.3 and denoted in Fig. 4 as the voice of the customer, the voice of the expert, the product/service life-cycle, and the information extracted from an extensive search of legacy databases. The output from the LIL is a set of innovation-promoting requirements. Depending on the resources and the environment of the LIL, the requirements produced may be ready for implementation, but most often will require additional processing by the internal evaluation team as indicated in [25].

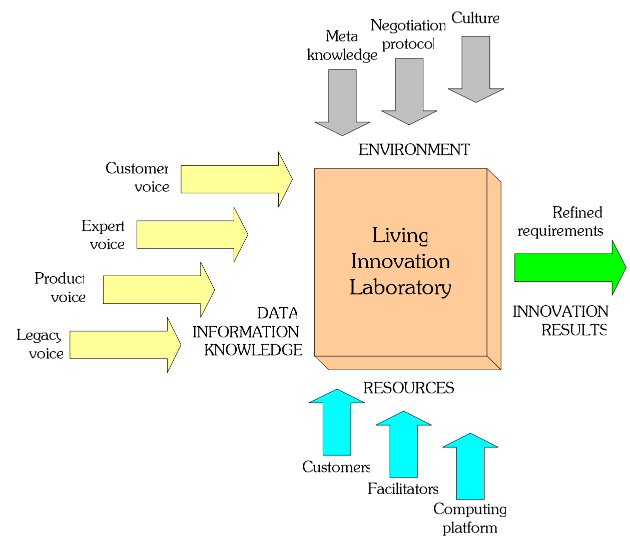

Fig. 4: The concept of the Living Innovation Laboratory.

The resources of the LIL are the customers and facilitators coordinating the LIL process, as well as a computing platform. The environment (the control is SADT) involves meta knowledge, negotiation protocols, and even the LIL culture.

4.2 Co-creation

The Living Innovation Laboratory is intended to co-create artifacts. Reichart [48] divided the co-creative product development process into four phases:

I. Product/service idea generation
II. Product/service concept creation
III. Product/service development
IV. Product/service launch

For the purpose of this paper, additional phases of the product/service launch phase have been created, thus leading to the following artifact's life-cycle process:

I. Artifact idea generation
II. Artifact concept creation
III. Artifact development
IV. Artifact production
V. Distribution
VI. Service and warranty
VII. Retirement

The success of the Innovation Living Laboratory depends on its organization, resources, methodologies, and the tools it offers, including a highly human interactive environment. Thomke and von Hippel [59] argued that the users rather than the manufacturers of technology were more often the source of innovations.

An example of a tool to be included in the Innovation Living Laboratory is discussed in the next section.

4.3 Innovation Modeling: An Expanded Dependency Model

The requirements-driven perspective advocated in this paper has numerous merits. Many will agree that it is valid, as it draws on a broad range of requirements such as function, form, culture, surprise, emotion, and categories to be discovered in the future. Furthermore, a multi-source approach is proposed for the generation of requirements. The innovation-fostering requirements make a subset of all requirements, and they are expressed through function and form, as well as other ways, e.g., a new service model or novel marketing.

For the expanded set of requirements, a relationship matrix with the artifact's functions and forms is built. A similar concept has been previously used with success in quality function deployment [23], the dependency structure matrix [9], group technology, and systems decomposition [32].

The rows of the proposed dependency matrix are the requirements collected from the four sources discussed in the paper, while the columns include product functions (or product parameters), process functions (or parameters), and parameters representing other pertinent product life-cycle phases. In addition to the row-column matrix, one can certainly consider row-row and column-column matrices to gain additional insights into the relationships between the requirements themselves, or the parameters characterizing the product, process, or other life cycle phases.

Depending on the goal of innovation analysis, the innovation matrix will take different forms, and it will become the basis of the innovation model. The model built, based on the matrix, will allow the introduction of various constraints and objective functions, thus covering diverse innovation-optimization scenarios.

Additional methods, methodologies, and tools of the Living Innovation Laboratory are discussed in the next section.

4.4 Distribution of Innovation Methods, Methodologies, and Tools

Each of the four basic phases of the product/service development process is supported by methods, methodologies, or tools [54]. Of course, different products and services may call for a different allocation. An illustrative assignment of traditional and computerized methods of the four-phase development is shown in Table 1.

Letter	Method Name	Traditional	Computer-based	Life-cycle Phase
B	Brainstorming sessions	x		I
C	Concept tests with lead users	x		II
	Conjoint analysis	x	x	II
	Creativity groups	x		I
	Customer complaints	x		I

	Customer suggestions	x		I
D	Dynamic social network logging		x	III
E	Empathic design	x		I
	Engineering contests	x		III
	Experience sampling method		x	III
	Eye tracking		x	IV
F	Field trials	x		III
	Focus groups	x		I
I	Interviews	x		I
	Idea generation with lead-users	x		I
M	Market intelligence service		x	I
O	Online creativity groups		x	I
	Online focus groups		x	I
	Online interviews		x	I
	Online suggestion box		x	I
P	Participatory design	x		I
	Product testing	x		IV
	Prototype testing	x		III
Q	Quality function deployment	x		II
S	Story telling	x		I
T	Test markets	x		IV
	Time-motion studies		x	IV
U	User design		x	II
	Usability tests	x		III, IV
	User toolkits		x	III
V	Virtual product tests		x	IV

	Virtual prototype tests		x	III, IV
	Virtual test markets		x	IV
W	Workshops with customers	x		III

Tab. 1: Illustrative classification and assignment of innovation-fostering methods.

The proposed Living Innovation Laboratory can be implemented in a variety of settings, ranging from university to corporate environments. The results (innovation requirements) produced by the LIL will not lead to innovation unless they are embraced by the corporation. Some of the lessons learned from the past innovations are discussed in the next section.

4.5 The Lessons of Innovation

The enthusiasm for innovation as a strategic driver of corporate growth appears in waves; however, with every wave of innovation, executives make mistakes [43]. Most of the time, they stumble in their R&D efforts due to the necessity to protect existing revenue streams while at the same time attempting to coax along new ones. Despite this balancing act, innovation can flourish if the lessons from the past are considered. Moss Kanter [43] has grouped the lessons learned from the past experience in the following four categories:

Strategy Lessons

- Not every innovation (here set innovation requirements) has to be a blockbuster. A number of small and incremental innovations can lead to success.
- Innovative ideas can be generated beyond product development, e.g., in areas such as manufacturing, finance, supply chain, and marketing, as advocated in this paper.
- Successful innovators use an “innovation pyramid” with several large ideas at the top that receive most of the attention, a portfolio of promising mid-range ideas in their test stage, and a broad base of ideas or incremental innovations in their early stage. The hierarchical AND/OR tree of requirements introduced in Section 3.2 supports this notion.

Process Lessons

- Tight controls limit innovation. The planning, budgeting, and review activities may slow down innovation efforts. The control aspect is signaled in the LIL with environment (the top-down arrows in Fig. 4).
- Companies should expect deviations from plans. If employees are rewarded simply for doing what they are supposed to do, rather than acting as circumstances would suggest, their employers will stifle creativity and destroy innovation.

Structure Lessons

- Tightened interpersonal connections between innovation efforts and other business functions shoule take place of formal controls. This is reflected in the LIL structure discussed in Section 4.1.
- Innovations may cut across established channels or combine elements of existing capacity in new ways.
- If companies create two classes of corporate citizens—supplying innovators with preferential treatment, privileges, and prestige—others in the company will make every effort to suppress innovation.

Skills Lessons

- Even the most technical innovations require strong leaders with great interpersonal and communication skills. Members of successful innovation teams stick together through the development of an idea, even if the company’s approach to career timing requires faster job rotation.
- Innovations depend on people (connectors) knowing how to partner with other businesses or the outside world, and they flourish in cultures supporting collaboration.

5. CONCLUSION

The potential of benefits due to innovation can be enormous. Despite many years of research, no formal framework that could be deployed in industry has been developed. The published concepts are plentiful, however, fragmented.

In this paper, a framework was outlined for innovation based on requirements elicited from multiple sources. As every innovation should lead to market success, any development process has to target the right requirements. With the abundance of data in the cyber world, new ways to acquire and analyze data are needed. The collected data and requirements are refined and analyzed by a group of tools and human resources all assembled as the Living Innovation Laboratory. Some of the ideas incorporated in the Living Innovation Laboratory have proven to be successful elsewhere.

6. ACKNOWLEDGEMENTS

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