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# INNOVATION: KEY ELEMENTS AND CHARACTERISTICS

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# INNOVATION: KEY ELEMENTS AND CHARACTERISTICS

## Introduction

In this paper we shall present the innovation process as a key factor for increasing a firm's competitive advantage. Using an innovation process typology, we will show how the innovation process affects the Business Activity Sequence (Riverola and Muñoz-Seca 1990 #14), improving the firm's operations and thus increasing its competitive advantage. We will differentiate between an *inner loop* of innovation, which creates learning, and an *outer loop*, which transmits this learning to the firm's operations. We will then describe how each type of innovation creates a different type of learning and how learning can be accelerated with the right type of training. Finally, we will suggest that the innovation process should be linked to the operational implementation of the firm's mission, and that one of the key elements of a firm's competitive advantage is continuous and systematic use of the innovation process.

## Previous work

In order to clarify and put the work presented in this paper into perspective we must briefly review previous work done by the author on the structure of a firm's knowledge base and the way it is generated and developed.

### *A. The structure of the knowledge base*

A firm's knowledge base can be divided into (Muñoz-Seca, 1991 #11):

- Pretechnological knowledge
- Technology
- Skills

*Pretechnological knowledge* is the knowledge base that generates the emergence of technology. We define *technology* (Riverola, 1991 #15) as structured knowledge for action and, thus, as an output, or evolution, of pretechnological knowledge. How does this transformation occur? If we pursue the idea that each component of the knowledge base has a different degree of abstraction, we can see that each component needs to be made more concrete at a lower level.

Thus, referring to the transformation path of the knowledge base, pretechnology is more abstract than technology and will be transformed into technologies, while technologies will be transformed into skills. We define *skills* as the ability to execute a specific activity, and *ability* as "an acquired proficiency in a particular activity resulting from interactions" (Muñoz-Seca, 1991 #11). Thus, skills are an acquired proficiency and are achieved by putting into effect, or using, knowledge on a very specific subject.

*B. The generation of knowledge*

We (Muñoz-Seca, 1991 #11) defined learning as the process of acquiring and storing knowledge. We showed that the core issue in learning is problem solving, and that the goodness of learning should be contingent on its long-run purpose. Learning implies changing the way tasks are performed in the future, and alters the way people act subsequently. We claim that learning through problem solving creates a *mental model* that recursively enhances people's learning capabilities and makes it easier for them to absorb new surrounding contingencies.

We also proposed a typology of learning, with three types of learning*: Know-how*, *know-why* and *global model*. *Know-how* learning is "task and procedure-oriented" and concentrates on improving people's skills and the organization of work. *Know-why* learning is "understanding-oriented" and creates a basis for improvement through precision in control and insight into the sources and structure of problems. *Global-model* learning consists of the changes that take place in a person's decision rules as a result of continuous use of a problem-solving methodology. Eventually, these changes alter the person's mental structure, which opens up and gains its learning capabilities.

In global-model learning, the individual develops, through constant problem solving, a new mentality, a new way of approaching any difficulty. The importance of problem solving lies in the fact that the agent gets to *own the methodology*, as it brings about changes in his mental structure. Thus, learning materializes in a *restructuring* of the agent's mental processes, a new *mental framework*. This is what we call the "capability for improved problem solving". Therefore, the problem-solving process does not just provide solutions to problems, but more importantly creates abilities that accelerate future problem solving by modifying the agent's mental structure.

Global-model learning thus has two levels: *Problem-Solving Model* and *Mental Framework*. Problem-solving learning is the learning that modifies a person's decision rules due to its continuous involvement in problem solving. Mental-framework learning is the next step, resulting in modifications in a person's mental structure, opening and expanding its learning capabilities.

The essential difference between problem-solving learning and mental-framework learning lies in the solving of *structured* and *unstructured* problems. Structured problems are those that can be solved by a known sequence of operations. The problem to be solved is known and knowledge guarantees the problem-solving process. The first step in solving them is to apply a series of known operations and implement certain techniques. Very often, a specific technique gives the solution to operational problems.

Unstructured problems are those in which the sequence of operations to achieve a solution is unknown. Usually, they are non-repetitive problems, and solving them involves redefining them. The first step is to try to define the problem and produce a diagnosis. Techniques become of secondary importance in solving the problem.

For structured problems, the agent learns through a methodology that solves and expands problems, giving the agent the flexibility to do so (problem-solving learning). For unstructured problems the agent must acquire a mental framework that, by enhancing his learning capabilities, accelerates the assimilation of innovation and transforms technological change into challenge.

Thus, global-model learning results in improved problem solving. This means that the worker, by his own motivation, can improve his performance, develop new capabilities and thus further increase his inventory of knowledge. It also implies that the firm benefits from this process, in that its performance improves and its workers develop new capabilities and accept innovation as a natural process.

*C. Developing the knowledge base*

In our previous work we argued that in order to enhance and consolidate these types of learning, a firm should adopt the TCA approach (Training for Competitive Advantage) to training. This approach links the firm's strategy with its training strategy, and the type of learning with the type of training. The TCA approach defines three types of training strategies: to acquire *skills*, to acquire a *portfolio* of technology, and to acquire a *mental model.*

The TCA approach embeds the acquisition of skills, technology and mental model in the firm's training strategy. To do this, the firm must become the active agent and take the lead in the training strategy. The firm's training action has an agent that is the recipient. This agent is the firm's workforce, which becomes the passive agent. This passive agent is faced with a set of problems with a given architecture. In order to solve them the agent requires certain abilities: *operating abilities* for structured problems, and *structuring abilities* for unstructured problems. Therefore, the firm's training strategy must be geared towards solving both type of problems and acquiring both types of abilities. The three training strategies (skills, portfolio and mental model), combined with the two types of abilities, become the key tool of the TCA approach. One of the key observations of the TCA approach is that training and learning are related by an action-response kind of relationship, and that training purpose and type of learning are linked. This relationship describes the type of learning that is achieved for each of the training purposes.

Having thus summarized the previous work that is relevant to our analysis of the innovation process, we will now proceed with this paper.

## The innovation process

The innovation process and its typology has been broadly studied. There are many definitions of innovation. They cover an ample spectrum, from "creating and introducing original solutions for new or already identified needs" (Quinn, 1979 #12) to "any change that has an effect on the company" (Marquis, 1969 #10).

Innovation has also been described as the development and successful introduction of new or improved goods (product) or production processes, giving to "new" the dimension of new to the firm, to the country or to the world; or as creating and introducing original solutions for new or already identified needs.

We will take a dynamic approach towards innovation and define it as a *process* that needs to be permanently ongoing in all enterprises if they want to maintain their competitive advantage. We will therefore describe it as a key factor of any successful[1] company.

To maintain long-term competitive advantage, a company needs to use its knowledge base efficiently. It has many different assets, but its most competitive, core asset, its *knowledge*, is often forgotten. The essential driving force of any company is the systematic, mission-oriented translation of the company's core knowledge into capabilities. Once a company has defined "its way to be best" (mission), it needs to put all its "knowledge base" to work to achieve that mission. It needs to materialize its knowledge.

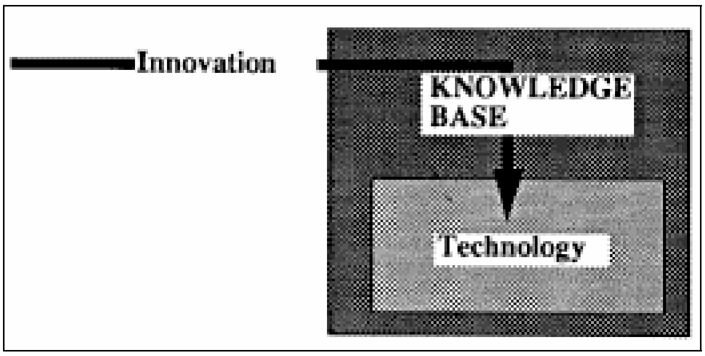
We shall distinguish between *transformation* and *materialization* of knowledge. Transformation is the process of evolution and change, and is internal to the person. Materialization is external; it is the achievement of a concrete and transferable objective form. Pretechnology, technology and skills can all be materialized in a broad array of forms, ranging from procedures and processes to symbolic forms.

In order to further pursue our analysis, we need to clarify the relationship between *innovation* and *technology*. Rogers (Rogers, 1990 #18) states that "a single item of technology is usually called an innovation, defined as an idea perceived as new. Technology is essentially a closely bundled set of innovations". We will take a somewhat different approach.

Since we have defined technology as "knowledge for action", technology is a type of knowledge. It is knowledge oriented towards its application to a particular end. In contrast, ***innovation*** is the ***process*** of using this knowledge. Innovation leads to *the incorporation of technology in a firm*. Innovation searches the firm's knowledge base for ways to raise the firm to a more competitive operational level.

## Figure 1

The relationship between innovation, knowledge base and technology




[1] We define success as the achievement of long-term competitive advantage.

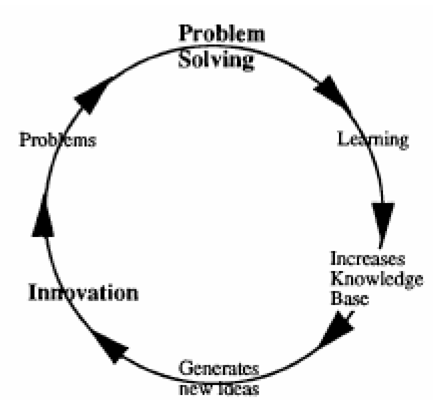
The essential point is that the knowledge base needs to be transformed into materializations than can give the firm competitive advantage. Thus, innovation mobilizes the company's knowledge base and becomes an intrinsic factor for the achievement of long-term competitive advantage.

After these considerations, we are now in a position to state our definition of innovation. In this paper, we will combine these ideas and define innovation as *the continuous dynamic **process** of **efficient utilization** of the company's knowledge base for doing things, old or new, in new ways.*

Furthermore, this utilization of the company's knowledge base is a self-reinforcing mechanism that feeds the knowledge base and alters its structure. The permanent search for ways to do things more competitively transforms the firm's knowledge base and thus increases the firm's knowledge and its technology and skills. This transformation is what we call "learning". It is learning that feeds the company's knowledge base.

To better understand the process, we shall further analyze the causal sequence shown in Figure 2. The effect of innovation is to create problems. Anything new or different gives rise to new problems. Thus, innovation brings into the firm *problems*[2] that need to be solved through a problem-solving process. *This problem-solving process produces learning* (Muñoz-Seca, 1991 #11). Learning increases the company's knowledge base and, in time, generates new ideas. The use of new ideas starts another innovation process, restarting the cycle. We call this causal sequence the ***innovation loop***. The innovation loop is the permanently ongoing process that feeds the company's knowledge base.

## Figure 2
The innovation loop




[2] We define problem as the existence of a situation that is not agreeable for a person (Pérez-López, 1991 #11).

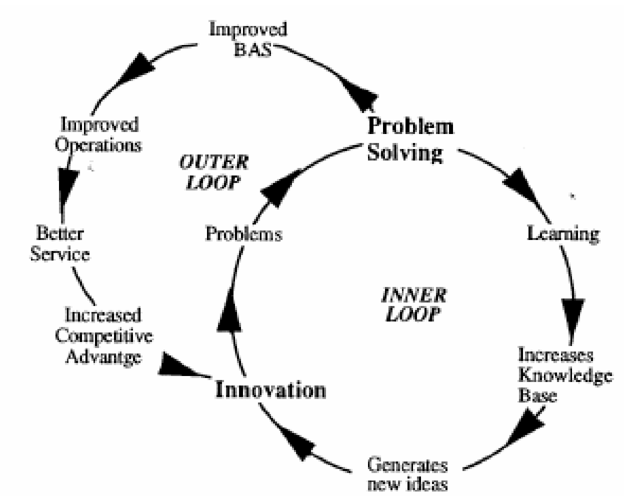
We can further develop this sequence by analyzing the effect of the innovation process on the Business Activity Sequence (BAS). A firm's BAS (Riverola and Muñoz-Seca #14) comprises all the firm's activities, starting from product generation and ending in a satisfied customer, that is, all the activities that assure long-lasting customer satisfaction. The BAS is a development of the Operations part of Porter's Value Chain. We claim that the variables that describe the configuration of each BAS activity are the right descriptors for the firm's Operational Structure in its service-providing role, and thus in the implementation of its way to be best. In (Riverola and Muñoz-Seca #14) we depict the BAS as a break-down of Operations, everything being oriented toward *serving the customer.*

Thus, if the innovation process increases the company's knowledge base, and the knowledge base is put to use by solving operational problems, we can deduce that the innovation process should improve the BAS and thus also the firm's operations. As a result, the firm achieves a better outcome from its operations and provides better service, thus improving its competitive position. This causal chain links innovation to competitive advantage and so describes the detailed process by which innovation becomes the source of such advantage. We call this the ***outer loop*** of innovation.

In Figure 3 we have combined the two loops, the innovation loop and the outer loop. We will call this combination the *innovation double loop*. The innovation double loop is defined by the old "innovation loop", now called the *inner loop*, and the new loop, *the outer loop*, which is generated by the effect that the innovation process has on the firm's competitive position through the BAS.

## Figure 3

The innovation loop

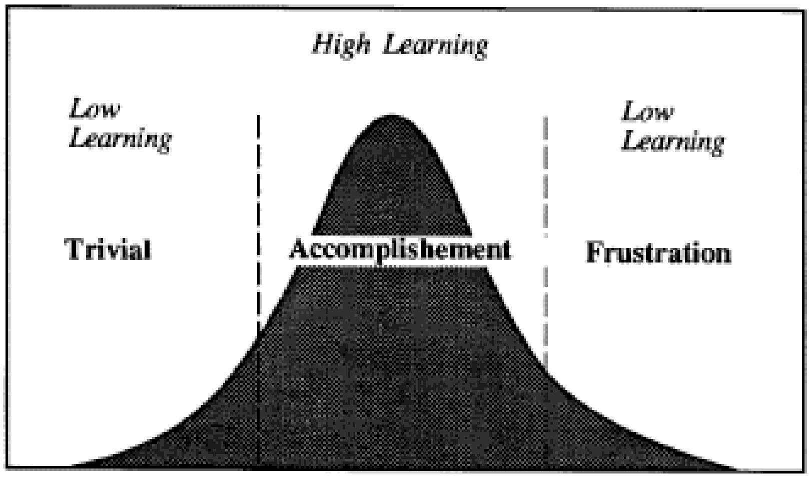



To better understand the innovation process, we now analyze the first effect of innovation: generating problems. We have said that innovation generates problems, and that problems have different architectures or structures: they can be either structured or unstructured. We could relate the difficulty of the problem to its structure. Structure is inversely proportional to difficulty. Thus, an unstructured problem is more "difficult to solve" than a structured problem. We can therefore relate the difficulty of problems with learning. De Treville (Treville, 1987 #20) uses Liebstein's idea that too much pressure leads to disorientation and confusion, while too little pressure leads to a lack of incentive. She links the difficulty of the problem to the challenge it creates for the solver. Low difficulty creates low challenge and very high difficulty creates frustration.

De Treville develops the idea that the level of challenge produces three learning effects: *trivial, accomplishment* and *frustration.* Low challenge creates trivial problems with little learning. High challenge creates a sense of frustration and lack of accomplishment, and also very little learning. And controlled challenge creates a sense of accomplishment and thus also high learning.

## Figure 4

De Treville Curve




*Challenge*

Amount of effort subject puts into task

With reference to De Treville's work, we contend that the difficulty of the problem is linked to the challenge the problem presents to the problem solver, thus giving rise to different degrees of learning. The effort to learn produces *different degrees of learning.* Only controlled challenges have a high learning effect. Since the difficulty of a problem is linked to the problem architecture, we can deduce that structured problems generally have a lower learning effect than unstructured problems. This leads us to conclude that there are different types of learning produced by innovation. To explore this issue and understand how the innovation process affects a firm, we must analyze the type of problem architecture that innovation generates. We do this by proposing an innovation typology that depends not only on problem architecture, but also on problem "variety".

## Types of innovation

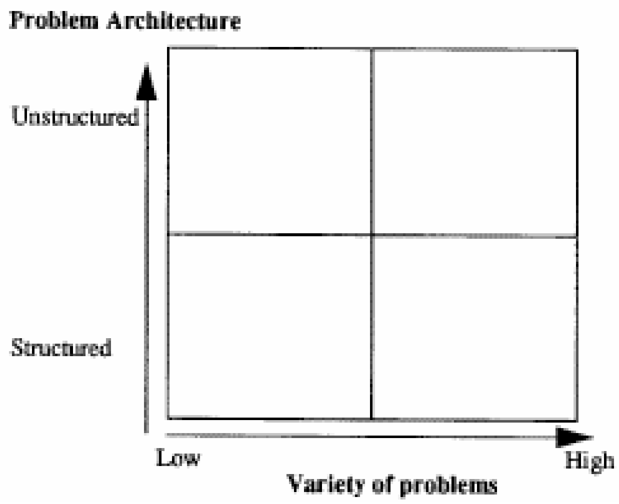
Problems may concern a wide range of subjects. We call this range the *problem variety* of the innovation process. Thus, we have two variables that we can use to define the innovation process:

1. Problem architecture
2. Problem variety

Combining these two variables gives us the *innovation matrix*.

## Figure 5

Innovation matrix




Combining the two axes, we end up with four categories: structured / low variety; structured / high variety; unstructured / low variety; and unstructured / high variety.

To give each combination a name, we have reviewed the innovation literature and have selected two innovation typologies (Marquis, 1969 #10 and Abernathy, 1985 #1) that are related to our ideas.

Marquis defines three types of innovation: complex, radical, and nuts and bolts. *Complex* innovation is the kind that results from thorough, long-range planning. In this type of innovation, managers' skills are essential to sort good approaches from bad. *Radical* innovation is innovation in technology that changes an entire industry. It tends to be produced by independent inventors. Finally, *nuts and bolts* innovation is intrinsically related to economic factors and is aimed at getting ahead of the competition. It is ordinary, everyday business innovation and technological change.

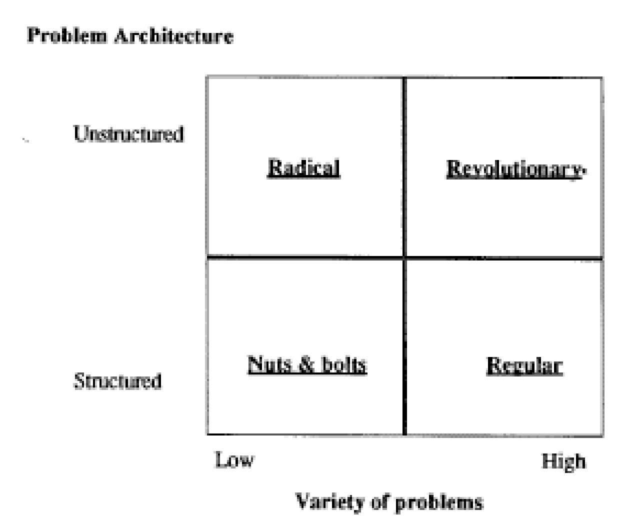
According to Abernathy, who looks at innovation from the point of view of its ability to change existing links, there are four types of innovation: architectural, niche, regular and revolutionary. *Architectural* innovation defines the basic configuration of products and processes. It stands out as creative acts of adapting and applying latent technologies to previously unarticulated user needs. Management must encourage the creative synthesis of information and new insight into users' needs with information about technological possibilities. It demands careful management of creativity and insight into business risk. The main tasks are: scanning for technological developments and orchestrating the combination of resources. *Niche* innovation opens new market opportunities through the use of existing technology. Timing and quick reactions are essential. Management must nurture speediness to enter the niche before a competitor seizes it. *Regular* innovation describes the change that builds on established technical and production competence and that is applied to existing markets and customers. Methodical planning and consistency are the key factors. Finally, *revolutionary* innovation disrupts established technical and production competence and renders it obsolete, yet it is applied to existing markets and customers.

We shall borrow from this terminology to define an innovation typology relating to our two variables: problem architecture and problem variety. *Nuts and bolts* innovation suggests to us situations of low variety and structured problems. *Regular* innovation suggests situations with a wide variety of structured problems. *Radical* innovation suggests the type of situation that generates a low variety of unstructured problems. Finally, *revolutionary* innovation suggests to us a situation with a high variety of unstructured problems. Therefore, we will use some of the above names for our four categories, as shown below:

1. Structured / low variety: Nuts and bolts Innovation
2. Structured / high variety: Regular Innovation
3. Unstructured low variety: Radical Innovation
4. Unstructured high variety: Revolutionary Innovation

## Figure 6

The innovation typology



This does not imply that the categories suggested by our use of the above names are identical with their original meaning. A discussion of the relationships is still a matter of speculation and will be the subject of forthcoming research. However, we feel that the typologies are close enough to deserve the assigned names.

## A framework for innovation

In this section we suggest a framework for understanding the effects that innovation has on company life. We will merely provide general indications and suggestions. Every company is a world unto itself, and we will not even try to categorize the richness of life in our framework. We would just like to point out some key issues that seem relevant to us and that provide a somewhat different way to understand innovation.

We start by analyzing the effect of the problem architecture on the evolution of the company's knowledge base. Linking our discussion of the innovation process with our innovation typology, we can say that the company's knowledge base undergoes incremental growth when either *nuts and bolts* innovation or *regular* innovation takes place. In contrast, *drastic* or *revolutionary* innovation gives rise to more of a qualitative leap in the company's knowledge base.

As long as the organization's knowledge increases when the knowledge of individual employees increases, it is in the organization's interest that the individuals increase their knowledge. This monotonicity assumption is a reasonable hypothesis in all but a few pathological cases. Therefore, we can analyze the increase of knowledge in the organization using our previous work, described above (Muñoz-Seca, 1991 #11), although it strictly applies to individuals.

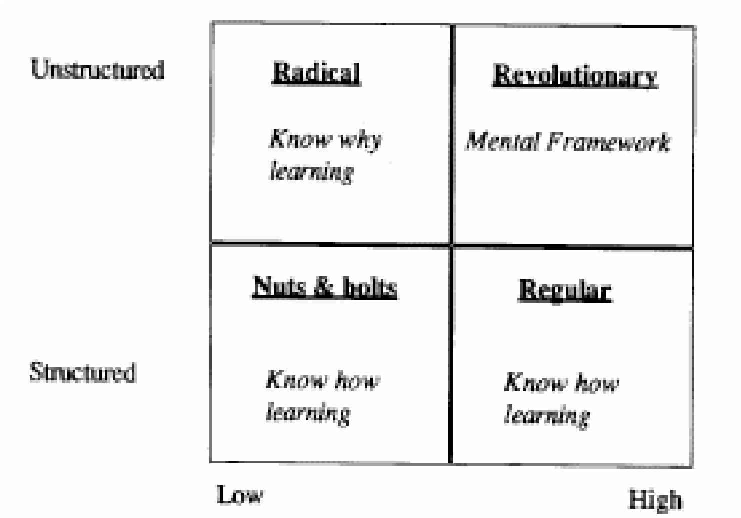
We will take a step forward in our analysis by hypothesizing a relationship between our three types of learning (know-how, know-why and global model) and the innovation matrix. The argument suggesting our hypothesis is simply a logical development of our previous analysis. Indeed, we already said that nuts and bolts innovation and regular innovation generate structured problems. And we said that solving structured problems produces know-how learning. Accordingly, we infer that nuts and bolts and regular innovation generate know-how learning. However, nuts and bolts innovation generates a low variety of structured problems, while regular innovation produces a high variety. This variety requires some further process of linkage and points to the possibility of a somewhat more complex problem-solving process, which could end up generating a Problem Solving Model type of learning.

Radical and revolutionary innovation generate unstructured problems. We have seen that solving unstructured problems results in know-why learning. Again, since we have a low variety of problems in radical innovation and a high variety in revolutionary innovation, this variety might produce a qualitative leap that requires and generates a different mental structure. The mental structure generated by solving unstructured problems is a mental framework. We suggest that radical and revolutionary innovation are the richest forms of innovation, as they generate mental-framework learning and thereby exponentially increase the knowledge of both the individual and the firm. The hypothesis linking the different types of innovation with the types of learning is stated in the following matrix:

## Figure 7

Learning in the innovation matrix

**Problem Architecture**




**Problem Variety**

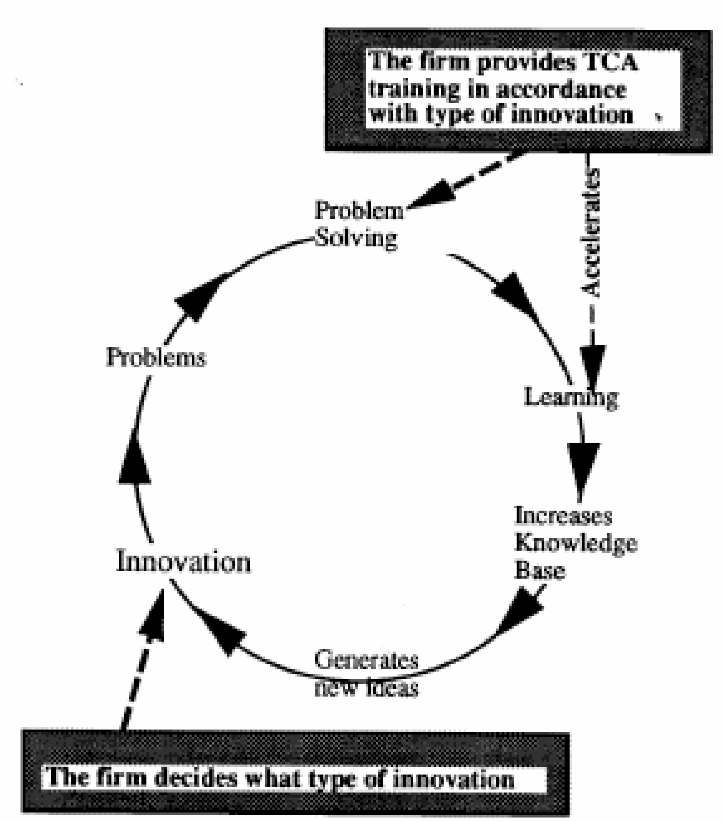
These relationships are clearly testable. We are currently conducting research into these associations.

Assuming the above hypothesis is true, we will go one step further in this model and link the firm's training strategies with the innovation process.

Our proposition is as follows. The firm can consciously control the innovations it requires. It can choose to have nuts and bolts, regular, revolutionary or radical innovation. This will generate different types and varieties of problems, which will generate different types of learning. Putting the above ideas together, we suggest that the causal link between training strategy and competitive advantage is given by the structure of the double loop model. The training strategy can accelerate the learning process to generate more new ideas faster. This will influence the innovation process, generating problems faster, with the desired variety and structure. Thus, by choosing the right training strategy, a firm can dramatically accelerate the inner loop, which feeds the outer loop and accelerates the double loop, leading to competitive advantage.

## Figure 8

The link between innovation and TCA



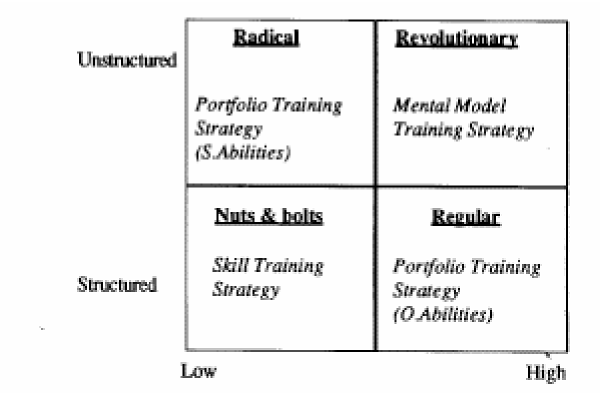

This hypothesis suggests that in order to accelerate nuts and bolts innovation the firm will need to implement a *skills* training strategy. In order to enhance regular innovation it will need to provide *technology portfolio* training (to solve structured problems). By contrast, in order to facilitate problem solving in radical innovation the firm will need to provide *technology framework* training[3]. Finally, in order to accelerate the assimilation of learning, through a revolutionary innovation strategy, the firm will need to help create a mental framework and so will need a *mental-model* training strategy. Again, this correspondence provides a way to test our hypothesis and will be the subject of further research.

[3] In our TCA model, we have called this Portfolio structuring abilities training.

## Figure 9

Learning in the innovation matrix

**Problem Architecture**




**Problem Variety**

# Policy implications

A firm should "consciously" design its training strategy to link it to its innovation process (strategy) in order to enhance its learning and its knowledge base. Clearly, a firm needs to choose its innovations in a certain order. Radical and revolutionary innovation is an "exhausting" experience for a firm. The difficulty and variety of the problems drain so much energy that the firm needs a "quiet period" to fully assimilate the change in its structures. We could draw a parallel between the innovation effect and the seasonal cycle of nature. As in nature, a firm needs quiet times and dramatic times. Winter is a "quiet" time in nature, spring and fall are "extreme" times. In its "extreme periods", a company will have either radical or revolutionary innovation. Radical and revolutionary innovation has a greater cost for the company – in terms of time, effort, adaptation and change. A company that has been through this process needs to recover from the effort and find peace in daily routine: those will be its "quiet periods". Nuts and bolts and regular innovation are the processes by which a firm adjusts its routine and improves the solutions found through radical and revolutionary innovation.

To further validate our reasoning, we have built a systems dynamic model for the whole process. We have found that it is extremely difficult to stabilize the growth of a constantly innovative company. The only way is to alternate extreme periods and quiet periods. We have found that in quiet periods we have to adjust the "forgetting rate", that is, the rate at which the company loses knowledge due to lack of challenge and problem solving opportunities. The forgetting rate comes from the stream of personnel leaving the company or the rate of attrition due to not using the firm's knowledge. A firm cannot endure constant radical and revolutionary innovation. But it needs to have a continuous improvement process, and that can be achieved through nuts and bots and regular innovation. We suggest that this type of innovation is the antidote to the "forgetting" rate and so is a key factor in the firm's quest for competitive advantage. We must emphasize the importance of these types of innovation, even though we have said they are not a great source of learning. If they are used continuously, they generate a "problem-solving" mentality, which can be enhanced with the right training. This gives the firm an enhanced learning ability and a more flexible and resourceful workforce.

## Summary and Conclusions

In this paper, we have tried to summarize our ideas about innovation. We have defined innovation as the process of efficiently putting the company's knowledge base to use. Once a company has defined "its way to be best" (mission), it needs to put all its "knowledge base" to work to attain that mission. It needs to be constantly searching for new ways to do it. This process is what we call innovation. The innovation process mobilizes the company's knowledge base and becomes an intrinsic factor for achieving long-term competitive advantage.

We have explained the innovation loop, in which the core of innovation is the creation of problems, which, when solved, generate learning. Learning increases the company's knowledge base. We have presented the *innovation double loop*, which links innovation with the firm's operations and thus with the firm's competitive advantage. The fine-grained structure of the inner loop has also been presented.

We have suggested that each type of innovation generates a particular type of learning and that in order to accelerate this learning a firm could link it with a specific type of training.

In summary, innovation provides the instantaneous flow of resources needed to keep the firm alive and working. In this paper, we have presented insights that may be used to manage innovation, starting with the company's training strategy and ending with competitive advantage. Thus, we have linked the firm's mission with a specific training strategy, which is associated with an innovation process and thus with constant learning to "feed" the firm's knowledge base.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