Innovation as a Two-sided Coin with Special Consideration of Analogies

Gerald Steiner
Institute of Innovation and Environmental Management, University of Graz, Universitaetsstrasse 15, A-8010 Graz, Austria, gerald.steiner@uni-graz.at

Abstract

Innovation is not only fruitful, it can also be harmful and might even cause serious damage within the organization or within its environment. Based on a systems thinking perspective it is therefore the main objective within this paper to have a look at the often overlooked – and at first glance negative - side effects, and their interaction with the fruitful effects of an innovation-orientated organization. Or to put it differently, the objective is to provide a holistic perspective of innovation from a systems thinking point of view. The origin and underlying mechanisms are of core interest. Further, inappropriate application of the analogy-based generation of innovation and potential counteractions is discussed. Similar to Fritjof Capra's thoughts on a dynamic balance between Yin and Yang, various different effects on innovation and creativity have to be taken into account. The second part of this paper discusses a specific example of a potential fruitful outcome along with a simultaneously potential harmful outcome and, the application of analogy-based learning for technical and socio-economic development with special regard to Darwin's concept of natural evolution.

Keywords: Innovation, analogies, creative destruction, Yin and Yang of innovation, systems thinking, biomimetics, Darwin

Introduction

Continuous changes characterize today's society and call for creative behavior and meaningful innovations. Traditional behavior that provided so long for success now has to be rethought, partly adapted and replaced if needed. On the way towards innovation, the creativity of individuals, teams, organizations, networks, clusters, and whole cultures seems to be a prerequisite. However, intrinsic motivational aspects, for example deeply felt fun and joy and strong commitment and appreciation, and also a behavior characterized by strength and competitiveness are only one side of the coin with regard to creativity and innovation.

Similar to Schumpeter's principle of creative destruction, most systems react with resistance and inactivity when changes to their own systems become an option. The roots of this behavior can be seen in a basic fear of the uncertain future system's conditions and, further, the fear of redundancy of previous systems and processes or, at worst, the destruction of those.

Applying Fritjof Capra's philosophical perspective of a dynamic balance between Yin and Yang to the phenomenon of creativity *(Capra, 1998)*, besides the likeable effects of creativity, the often overseen and more or less unwelcome effects of it and especially the interaction between the various systems elements – such as welcome and unwelcome effects – also have to be

considered. It is the dynamic balance that needs to become the central focus of investigation.

Essentially, in order to provide for a more holistic picture of creativity, the potential dangers of creativity are given special consideration here, since they are mostly overseen or neglected. Therefore, not only the results of creative problem-solving processes or creative processes in general are of interest, but also the processes leading to the creative outcome have to be viewed more critically: Creative thinking processes call for both convergent and divergent thinking. For this, the ability to generate associations is crucial, such as is the case by introducing analogy-based thinking modes. Further, an impressive number of methods is provided by fields such as research and development or innovation management that rely on analogy-based thinking modes, i.e. synectics, biomimetics, serendipity (word-)associations and others. Although it cannot be overlooked that those mechanisms have led to impressive developments, especially in engineering and biomimetics, it is the objective of this contribution to show the other side of the coin by stating that analogy-based thinking modes as a means to generate creative outcomes and innovation can be dangerous or even disastrous because of inappropriate understanding of the underlying system.

Going a step further by establishing an analogy from Darwin *(1979)* to economics: From a systems science point of view, is the application of Darwin's natural evolution and selection principles to economic processes and market mechanisms something desirable or not? Although often found in literature, based on a specific example I will demonstrate some of the limits of analogy-based developments with respect to various system's characteristics, such as the speed and characteristics of change in the behavior of a system, the suggestibility of a system, and the learning capabilities of a system. Furthermore, the crucial role of the user or problem-solver must be pointed out. Whereas copying a system's mechanisms may seldom lead to success, the process has to lead from firstly trying to understand the various system's peculiarities and secondly critically searching for the systems mechanisms that can be modeled with respect to a set of carefully identified objectives. If, on the other hand, this is carelessly applied, the result might even lead to such disastrous outcomes such as supported by social Darwinism and leading to the tragedy of the Nazi Holocaust.

In order to meaningfully use analogies, specific system's conditions are required in order to allow learning among different systems. These are to be discussed in detail as a crucial part of this contribution.

Innovation: A Systems Thinking Perspective

Innovation can be considered as a two-sided coin. Based on superficial characterizations innovation is often understood just as a promising new way, the only opportunity to cope with change, accompanied by creativity, and with the final consequence of leading to higher competitiveness and success on the market. The following contribution discusses the effects of pro and contra innovation-oriented organizational behavior and also the interplay of the diverse effects of innovations for the organization itself and also for its environment. This description is based on a systems thinking perspective. Hence, a further question is to what degree a synergetic collaboration of an opportunistic and resistant behavior towards innovation is feasible for achieving an overall improvement of the organizational system?

Creative destruction and resistance towards innovation

Usually, the introduction of something new within the organization or the market is always

accompanied by the destruction or removal of former structures, processes, and products. Hence, Joseph Schumpeter introduced the expression "creative destruction" for this process of transformation that characterizes especially radical innovation, whereby the entrepreneur is the one who disturbs an economic equilibrium by bringing innovation into the world and therefore causes economic and social development *(e.g. Schumpeter, 1934; Schumpeter, 1942; Schumpeter, 2005)*.

Nevertheless, Schumpeter is not considering the whole innovation system. For example, with regard to the innovation process Schumpeter does not directly consider the link between the generation of innovation and its diffusion on the market. By pointing out the simultaneous effect of destruction Schumpeter made an important first step towards a more holistic understanding of the innovation system. However, the stakeholders concerned by this creative destruction, their motives and attitudes, and potential strategies for dealing with this, including inter-personal issues, have not been addressed extensively by Schumpeter.

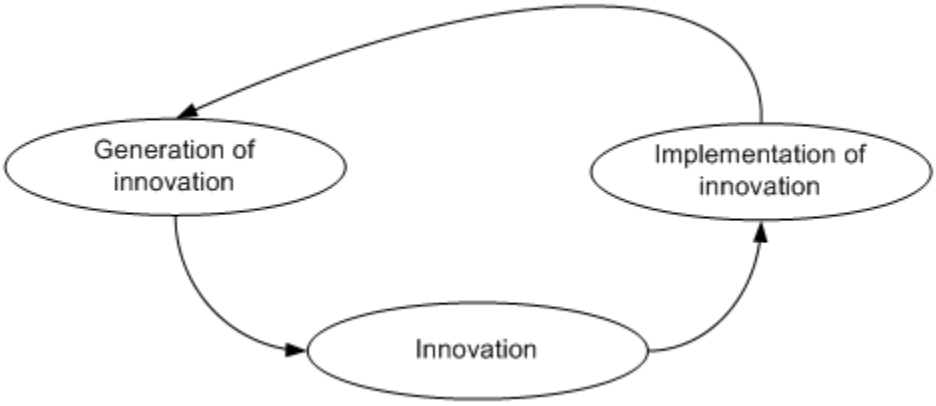

Figure 1: From generation to implementation of innovation

In order to point out the diverse effects of innovation, one has to be aware that the organization generating innovation and the one that is implementing innovation as a part of the diffusion process on the market are not identical but usually two (or more) different entities. Therefore, the reasons for favorable and resistant patterns of innovation behavior have partly different origins in each case. Besides this, one needs to be aware that the organization generating innovation does not have to be innovative with regard to inner processes. On the other hand, an innovative and creative organizational climate is not automatically linked to saleable innovative products.

Based on an organizational level, what are the aspects that might hamper a proactive attitude? In order to generate or implement innovation, organizations usually have to accept

- a higher level of uncertainty of future developments and their outcomes,
- consequently also a higher degree of risk (especially when talking about radical innovations), and
- possible resistance to the innovation within the own organization because of needed changes in previously successful and now overcome patterns of behavior.

Further, the higher the degree of innovativeness of the generated product, the higher the overall risk of failure is: for radical innovations not only the potential future market and its customers is more or less indeterminable, but also the costs for building up such a market are tremendous.

If innovation is implemented within an organization – e.g. as process innovation leading to restructuring of the production line – within the organization there will be both stakeholders with favorable but also resistant behavior. Favorable patterns of behavior will be shown by those whose expectations regarding the overall effects of the implemented innovation are positive. If the overall effects are negative, those stakeholders will show resistance and consequently refuse innovation.

Before considering further patterns of behavior with regard to innovation, the linkage between change and innovation, potential hurdles within the innovation process as well as the role of promoters to overcome them are discussed briefly based on innovation research literature.

Strategies in dealing with hurdles of innovation based on innovation research

Change has become the determining factor of most facets of life. Further, creativity is the basis of every successful innovation as the means to cope with change *(Peters, 1993, 44; Amabile, 1997, 40; Utterback, 1994; Ulrich, 1994, 7–14; Ford and Gioia, 1996, 878)*. It seems to be obvious that the more creativity is needed the higher the degree of innovativeness is, or in different words, radical innovations require more creativity than incremental ones (for further detailed distinctions between incremental and radical innovation, see for example *Christensen (2000)* but also Christensen and Overdorf *(2001, 103–130)*).

This "obvious" principle of cause and effect links external change, the necessity to generate a more appropriate set of incremental and radical innovations, and the need to creatively question every thinkable status quo within the organization. It seems to be the universally valid law of today's business world. The tacit implications behind this seem to be:

- The organization has to react to changes in its environment such as e.g. actions taken by competitors and technological developments, since the organization is immediately coupled to its environment.
- Creativity is needed in order to develop the appropriate set of radical and incremental innovations and also keep the internal development process of the organization running.

More concrete, innovation research came up with specific suggestions to deal with resistance to the generation of innovation within the organization: Firstly, it seems to be necessary to be aware of potential hurdles such as barriers of inappropriate knowledge, a lack of willingness to innovate, administrative as well as bureaucratic resistance towards innovation, as well as specific barriers related to external partners; secondly, based on the knowledge of potential burdens, it is necessary to identify appropriate promoters – power promoters, promoters on the subject, process promoters, and relationship promoters – and to appropriately involve them within the intended innovation process in order to overcome the potential restraints *(Witte, 1973; Hauschildt, 2004; Hauschildt and Gemünden, 1999; Hauschildt and Chakrabarti, 1988, 384; Gemünden and Walter, 1995)*.

This approach provided for a further extension of the innovation view by specifically asking how "champions" can help to overcome hurdles within the organization but also within the interaction with external partners.

Nevertheless, it seems that the hurdles for innovation are purely considered as something bad that has to be overcome, changed, or terminated without seeing potential positive effect behind them. In the next section of this paper this view should be extended by further aspects relevant for the innovation system and its stakeholders.

The linkage between change and innovation: a principle of cause and effect?

In order to broaden the systems perspective of innovation and further to provide for an extended view of innovation-related patterns of behavior, two further questions are to be asked:

1. Is innovation the only response to change?
2. What positive effects can potential resistance towards innovation have for the organizational development?

Change: possibilities of response based on the concept of ontogeny

Ontogeny implies the history of structural change of the organizational system without losing its own organization, its identity. What are the implications of the concept of ontogeny on a situation in which the organizational system is exposed to changes within its environment *(Maturana and Varela, 1992)*? Generally speaking, the organizational system is operationally different from its environment, but they are structurally coupled. Consequently, changes in the structure of the environment might initiate changes of the organizational structure, but they do not determine them. Instead, the structural change of the organizational system can be initiated by its environment as well as by its inner dynamics *(Maturana and Varela, 1987, 84-86)*. Furthermore, structural coupling is always a mutual process. That implies that structural compatibility is needed in order to allow further development of the organizational system by the necessary processes of adaptation in order to survive.

What are now the conclusions with regard to a necessity to innovate? The answer is that innovation is not necessarily needed to provide structural compatibility as an answer to external changes in the environment. Instead, in the sense of a dynamic equilibrium (similar to the body temperature of human beings within the changing temperature of the environment) it shows that the compatibility of structures is not a one-way option. Further it shows how important it is to consider the inner peculiarities and inner dynamics of the organization, since this is itself an important source for initiating structural change of the organizational system. Consequently, in a situation of intense change within its environment it might, nevertheless - under consideration of the peculiarities of the organization - be a “fitting” strategy to show a stable behavior instead, rely on inner values and a strong vision, and continue with a proven behavior instead.

To sum this up, two potential strategies for reacting are the generation of innovation and (and this is often forgotten), also the reliance on sound traditional patterns of behavior in times of turmoil, but always in accordance with the whole meta-system, the interaction of the organization with other relevant systems and its whole environment. Creativity is needed in order to develop an organizational behavior appropriate to be flexible and adaptive enough to cope with change. This cannot be put on a level with applying creativity for the generation of innovation. The generation of innovation is one general option for an organization in order to fit into its environment; the specific situation might also allow keeping with tradition instead. If an organization tends to show proactive innovation behavior, it still has to be clarified whether the generation of innovation does refer to its interaction with the environment – e.g. by generating radical product developments – or more with regard to processes and situations within the organization – e.g. by the introduction of social innovations in order to support the organizational climate which furthermore might contribute to higher product quality, process improvements, and an improved cost situation.

Resistance towards innovation as a supportive means for innovation?

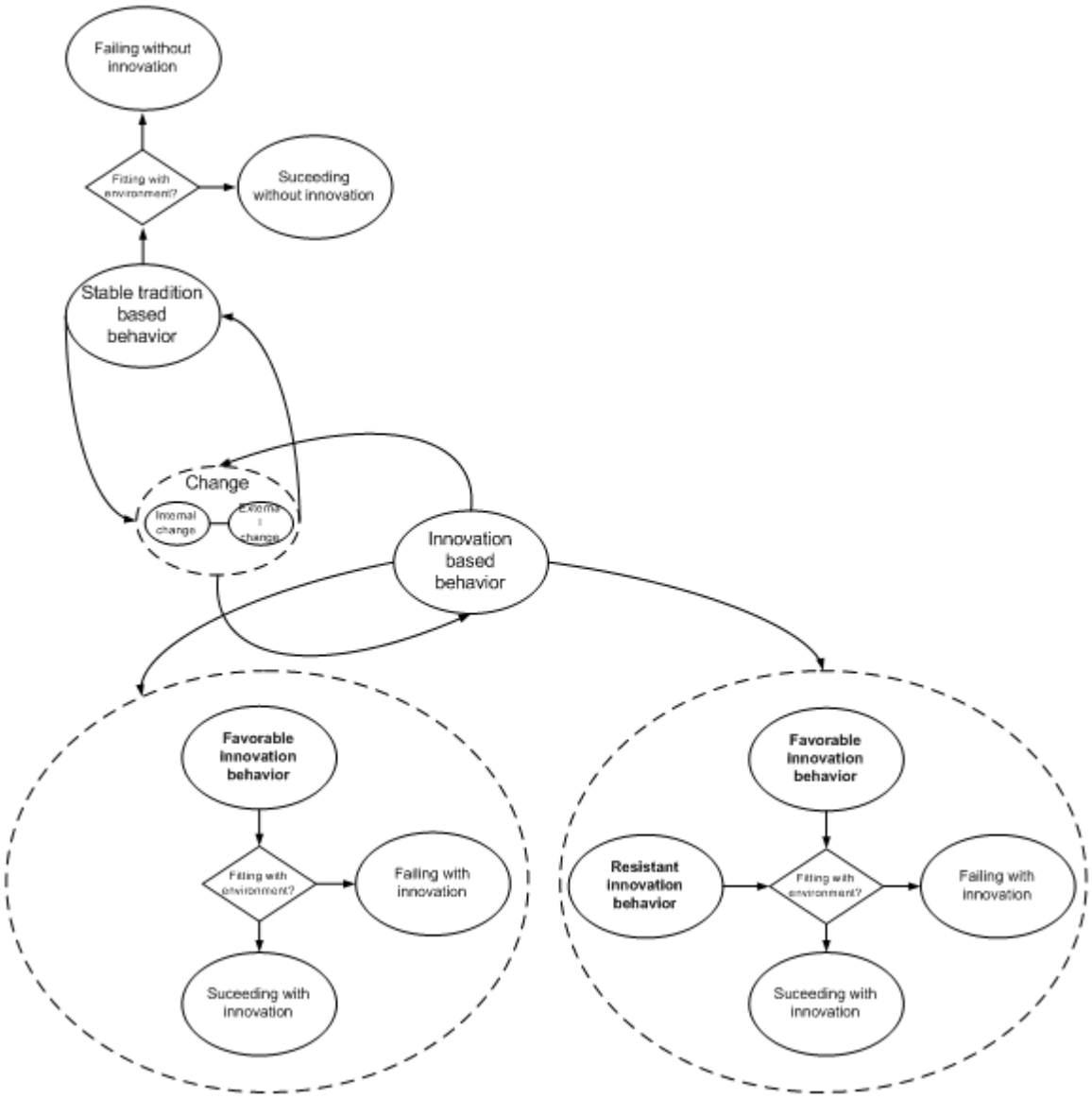

Figure 2: Change – innovation - tradition

Often praised as the only one alternative for organizations within an increasingly competitive world *(e.g. Peters, 1993)*, an attitude towards innovation can neither guarantee the organization's success nor its survival (see figure 2). The discussion in chapter 2.3.1 showed that situations of internal as well as external change do not necessarily favor organizations with a pro-innovative behavior. Instead it depends on the overall situation as to what strategy is more successful by developing a system behavior "that fits" in its environment.

With regard to innovation-based behavior figure 2 suggests that it is not only the aim of having an inner-organizational situation with the highest degree of favorable innovation behavior as possible – this might instead be contra productive because of not being aware of potential

dangers and hurdles – but that it is also important to find possibilities to integrate resistant innovation behavior as a supporting means for a successful development of the organization and also for generating more successful innovations. To put this together, if resistant innovation behavior is properly understood, this can contribute to

- a higher system sensitivity,
- using the reasons for and behind resistance as potential warning signals for later difficulties,
- more appropriate innovation,
- developing a better understanding of the phenomenon of sustainable innovation and sustainable development, and
- a generally more successful development of the organization.

Further, by integrating a resistant and favorable innovation behavior in the sense of accepting the potential fruitful outcome of the interplay of Yin and Yang, a symbiosis between promoters and opponents of innovation might be attained, the organization's vision might become more acceptable to all its members, and the overall development of the organization might better fit in its environment. In the philosophy of a meaningful balance between an adventurous attitude towards innovation and the resistance to innovation as a kind of warning function the question is not only how to overcome the resistance, but more how the warning perspective can be fruitfully integrated within the overall innovation strategy of the organization.

In the following, analogical reasoning as another influential aspect within the generation of innovation is discussed. In the same philosophy, this is not only about looking just at one side of the coin, but instead about understanding potential dangers and shortcomings in order to avoid getting lost within an uncertain development.

Analogical reasoning within creative processes

In general terms, an analogy is a structural and/or functional similarity of two or more systems which have basically different origins. In cognitive science, analogy is a means of understanding novel situations and problems in terms of familiar ones *(Gentner et al., 2002)*. Mumford and Porter *(1999, 71-72)* consider analogies as a mapping of similarities between two or more phenomena with prior problem-solving experience as the base for understanding a new problem. That means a base problem is used to draw inferences about a target problem. Thus, analogical reasoning can contribute to creative efforts by the combination and reorganization of extant knowledge structures. Therefore, by structure mapping overt similarities between the base and target problem can be discovered *(Genter and Markham, 1997)*. In a first step the problem-solver tries to identify similar elements or similar features. In a next step these linked elements are the basis for identifying subsets of connections between the base and target problem, and consequently these subsets are the basis for constructing an integrated explanatory structure for drawing inferences and developing solutions *(Mumford and Porter 1999, 73)*.

The principle of analogy can be found in various disciplines such as biology, physics, mathematics, rhetoric, law, and philosophy. Further, for the application of analogies within creative processes a distinction of analogical reasoning according the degree of activity can be helpful: An example of passive analogies would be facial recognition since the objective of analogical thinking is here to determine similarities in the system structures. By that the crucial role of analogies within cognition becomes obvious. But analogy is not only bounded to the

passive discovery of similarities for explanatory purposes, but also the active transmission of functions and structures from one system to another in order to create something new. Focusing on the active – constructive – application of analogies, a further distinction can be made by dividing those analogies into direct and indirect analogical processes. As pointed out in figure 3, explanatory analogies can nevertheless deliver additional insight within the process of building constructive analogies.

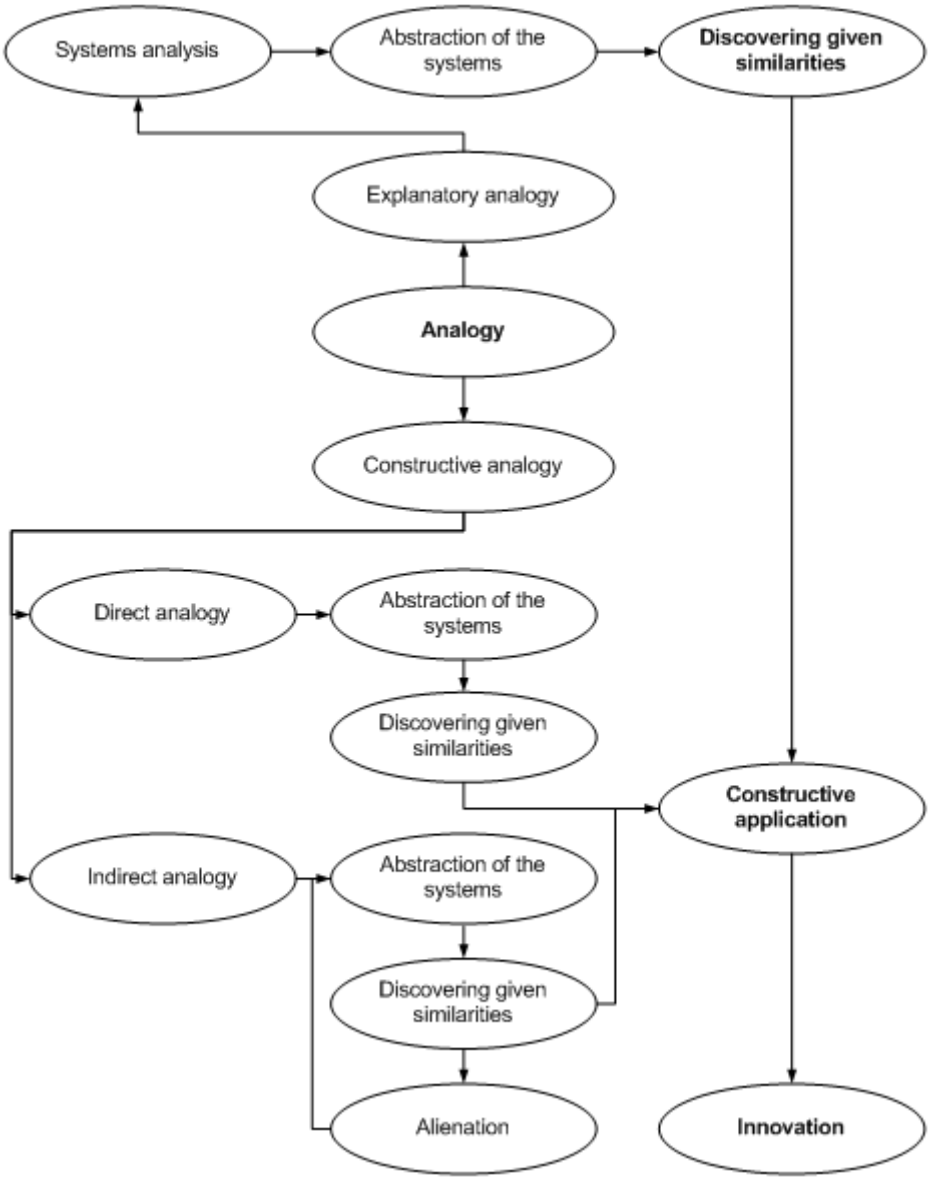

Figure 3: Forms of analogies within creative processes

The research field of biomimetics is an example for the direct transmission of functions and structures from a biological system to a technical application. An example of the indirect analogy is the application of synectics as a problem-solving approach to a given problem in order to get away from a fixed understanding of a system by the application of stepwise analogies in order to find highly creative but not obvious solutions to a given problem. Indirect and direct analogies are the basis of many creative problem-solving methodologies and methods such as biomimetics,

serendipity (word-) associations, synectics (as already mentioned) and others. It should be mentioned that in the application of some methods such as synectics, similarities between the base and the target system are not necessarily obvious in first stage. Instead it is often necessary to work with metaphors by lifting the original system understanding to a higher level of abstraction. Further, the objective of analogical thinking can be more to stimulate divergent thinking, helping the problem-solver to become freed from thinking paradigms that hamper the creation of new ideas (this is also one objective within the various process steps of synectics).

Generally speaking, from an epistemological point of view, active forms of analogies differ from deduction, induction, and abduction. The process of knowledge creation within the analogical thinking shows very much flexible and volatile behavior, where neither the premises nor potential solutions need to be generally approved (it should be mentioned that there are also authors who consider analogy as being a special form of induction and others who consider it a special form of deduction).

The sensitivity, subjectivity, and the individualistic meaning behind every kind of analogy could not better be described than by the title of the first chapter of the book "tree of knowledge" by Maturana and Varela that is "Knowing how we know" *(Maturana and Varela, 1992, 17)*. If the aphorism "all doing is knowing, and all knowing is doing" *(Maturana and Varela, 1992, 26)* is applied to analogy it becomes obvious that knowledge gained from drawing inferences between a base and target system is always connected to the problem-solver who is working with analogies. Going one step further and applying the second aphorism "Everything said is said by someone" *(Maturana and Varela, 1992, 26)* shows that in order to understand analogies they always have to be seen in context with the problem-solver. Even though the process of analogical thinking is described accurately, the outcome and its meaning will always generate a new world of knowledge in accordance with the applying persons and the structure of those persons.

In order to avoid getting lost within the process of analogical thinking and also with the objective in mind that the generated knowledge should provide for fruitful solutions, what are the prerequisites to be considered?

Prerequisites for analogy-based reasoning

In order to generate creative solutions for successful sustainable innovations the choice of the underlying base problem, base system for drawing inferences about a target problem or target system and the careful process of combination and reorganization of extant knowledge structures are crucial. The base systems have to be carefully selected for relevance to the problem and these cases have further to be applied flexibly as a tool for discovering relationships "rather than as a tool that simply ensures the repetition of past experience" *(Mumford and Porter, 1999, 76)*.

To put things together, based on systems thinking it seems that there need to be several prerequisites fulfilled or at least the given conditions have to be clarified for active analogy-based thinking within creative processes in other to improve prevailing knowledge structures:

- Is a holistic system understanding given (with regard to the "dialectical systems thinking theory" and "informal systems thinking" (Mulej, 1995; Mulej et al., 2003)? If base and target systems are not understood holistically, analogies will be based on an isolated or one-sided system perspective that might lead to insufficient solutions.
- Is the objective of the application of analogical thinking clarified? Possible alternatives are:

    - Drawing direct inferences from a base system to a target system.
    - Stimulating creative thoughts by freeing from prevailing paradigms.
- Do the systems' sets of objectives (of the individual and of the whole) show similar or compatible attributes?
- Is the underlying language or patterns of communication of the single systems comparable?
- Do the investigated systems show a similar degree of suggestibility?
- Are the systems characterized by a fitting degree of abstraction? In order to make similarities between the base and the target system visible, it could be necessary to find a fitting degree of abstraction. E.g. in some cases this might lead to a metaphorical comparison in order to make inferences possible.
- Do the systems show similar processes of development with regard to the pace of development?
- Do the systems show comparable learning capabilities?
    - What is the defined role of the problem-solver or user?
    - Is the learning role active or passive?

Whereas copying a system's mechanisms may seldom lead to success, the process has to lead from firstly trying to understand the various system peculiarities and secondly critically searching for the systems mechanisms that can be modeled with respect to a set of carefully identified objectives.

Cases of analogy-based learning for technical and socio-economic developments based on natural systems

Analogy-based thinking must be considered as a kind of meta-tool that can be applied to various system levels, as problem-related application such as within a creativity supporting technique or even the underlying thinking paradigm of a scientific field such as biomimetics (in German "Bionik") or as a scientific-philosophical basis such as within ecology, economics, and ethics (e.g. "Bumblebee Economics" by Bernd Heinrich *(1979)* or "Gaia Connections – an Introduction to Ecology, Ecoethics, and Economics" by Alan S. Miller *(1990)*, or "GAIA – the Practical Science of Planetary Medicine" by James Lovelock *(1991)*).

Biomimetics, also called bionical creativity engineering, or in German "Bionik", is an example of a scientific endeavor for drawing inferences based on a natural system to an engineering problem or a technological system. This kind of combined research has been responsible for incredible developments in engineering and architecture *(Nachtigall and Blüchel, 2000)*. Nevertheless, this kind of "learning from nature", where nature serves as a model for technological development, differs in many aspects in comparison to learning processes within socio-cultural and socio-economic systems. Biomimetics is mostly based on one-sided linear learning, not mutual learning between the biological and the technical system. E.g. technical systems learn from nature, but the same is only true the other way round in a very limited sense. Furthermore, nature is mostly considered as a kind of blue-print, especially in the dominating fields of biomimetics such as architectural biomimetics or construction biomimetics. In those cases the underlying biological mechanisms, functions, structures, and forms might be characterized by the interplay of a vast number of elements, typically in most cases the structure of the observed system does not change over time.

Consequently, whereas the learning for technical structures and architectural entities can obviously provide for meaningful contributions, the social forms of biomimetics such as those

based on evolutionary developments in nature are far more critical. Although there is a lot to learn from nature, the engineering world has to be aware of how different the various systems perceive themselves and their environment: Take the example of a dolphin or a bat, first of all one has to be aware that the dolphin's world perceived by a human observer is very much different from the dolphin's own perception *(see also the examples by Nachtigall and Blüchel, 2000, 12)*. That implies that additional to the individual perceptions of a certain system by members of the same species, in the case of analogy-based perceptions the different senses, available sense organs, and the different levels of performance with regard to specific sense organs also have to be taken into account.

In order to demonstrate the difficulties of such analogies, the phenomenon of natural selection is taken as an example for analogy-based learning.

Can organizational development learn from biology and Darwin's concept of natural selection?

There are several analogies that can provide meaningful support for developing strategies and behavior for coping with change. A fruitful example might be to learn from natural biological systems with regard to dynamic equilibrium in the sense of thermodynamics: By considering the interplay between a system and its environment, what associations are possible between an organization acting in correlation with its environment (customers, competitors, suppliers, special interest groups, government, and further stakeholders as well as technological developments and others) and a biological system in interaction with its natural environment? Since the equilibrium states of many determining inner factors of the biological system differ explicitly from the equilibrium states of the environment, what associations can be drawn between the biological and the organizational systems (a widely cited example is the case of the constant body temperature of most mammals in relation to changing temperature in the environment)?

Another example: One of today's dominating tasks for organizations is to develop a behavior that is appropriate for coping with the increasing changes in the organizations' environment. By doing so learning from different systems is a popular choice. At this point I will discuss whether Darwin's natural evolution and especially the concept of selection is suited to be applied to the development of social systems such as organizations. By taking into account the previously discussed prerequisites for analogy-based thinking some fruitful but also some critical issues for applying analogy-based thinking in this specific case become obvious:

Both the system of evolution and also the development of an organization are composed of a large number of interacting components. Further, in both cases small interferences might have a tremendous effect on the overall system based on non-linear interactions within each system. By considering that randomness is very much determining those systems it helps the observer to better understand that such systems cannot be predicted but at most patterns of behavior might become visible. That implies also that analogy-based learning refers in this specific case more to a higher level of abstraction. According to Gould the only permitted analogy between evolutionary theory and human cultural systems such as organizations is that variability is positive for the system's development and as a consequence flexibility, different strategies, regionalism, ability to change, variation, and the ability to consider many different alternatives are also principally positive for the development of systems, or the other way round: systems that show very rigid pattern of behavior in one direction don't last very long *(2002, 23,28)*. By having a closer look at the concept of natural selection analogy-based learning seems to show some fundamental inconsistencies with regard to

- learning capabilities,
- the degree of suggestibility, and to
- the pace of development

of the system of natural selection in comparison to the development of an organizational system.

Because of those reasons, the biologist Stephan Jay Gould states that "the attempt to apply natural selection theory – the adaptation of a species to changing local environments – to the business world is wrong in principle", since the mechanisms of human cultural systems are quite different from those in natural systems *(2002, 20)*. Whereas in human cultural systems acquired knowledge and characteristics can be forwarded to the next generation by learning, this mechanism is not, or just in a very limited form, available in nature. Furthermore, Gould considers the differences in separation and suggestibility irreconcilable for applied analogy *(Gould 2002, 18,22)*: Separation within biological system is forever: nevertheless the system can interact ecologically with other systems but it cannot join with them and create a new system. Human cultural systems, on the other hand, show this attribute as well: managers might leave a company, acquire experiences in another company, and leave this company and join the former company again to synergistically contribute to its knowledge base, what is also called cross-penetration. Besides, the cultural change based on the system's learning capabilities correlates strongly with the pace of development: whereas there has been no biological change in humans for 40,000 or 50,000 years. Nearly everything humankind has built called culture and civilization is based on "the same body and brain" *(Gould 2002, 27-28)*.

Furthermore, in order to draw valid inferences between natural evolution and the organizational system, the question whether the base system is sufficiently understood has to be discussed in more detail (see also the discussed prerequisites for analogies in chapter 3.1 of this paper). Especially from a systems thinking perspective the appropriateness of Darwin's concept of natural selection is in doubt *(e.g., Wesson, 1991; Maturana and Varela, 1992; von Bertallanfy, 1968; Riedl,1975; Riedl, 1978)*. Taking a look at what Maturana and Varela *(1992, 93-119)*, call "natural drift": Accordingly, evolution is a natural drift as a result of maintaining autopoiesis and adaptation of a system, structural drifting with continual phylogenetic selection while a living being and its environment stay in continuous structural coupling. However, it is not an external force such as a selection by the environment that is responsible for the variety and complementary systems behavior. Therefore, evolution is not about optimizing specific qualities of any living organisms or the optimization of utilizing the environment.

If, according Maturana and Varela, it is not natural selection but natural drift that is the driving force behind evolution, consequently the so-called and within the business world often cited "survival of the fittest" or "survival of the strongest" or "survival of the best adapted" or "optimization" is basically insufficient. Beyond this those assumptions based on such a base system might also lead to inappropriate decisions with ruinous consequences for the organization.

Although it is nowadays critically called into question by many biologists, the analogy between natural selection and competition is still alive within the business world and is not questioned there massively. The cause behind this lethargy is that the system affected by the original analogy will show delayed reactions to changes of the underlying former analogy. In order to change, the interfering updated analogy has to be a strong signal, which also needs to be accepted by the relevant decision-makers of the system. Otherwise, the updated analogy will provide for new possibilities of analogical learning but without any practical implication.

A summarization of potential dangers by inappropriately applying analogies

Analogies can find application as powerful creative thinking strategies for the generation of innovation. But applying analogies is not only about generating innovations with positive as well as potentially negative effects on the different stakeholders, it is also about appropriate and inappropriate practices in the innovation process itself.

To summarize, in order to avoid misinterpretations and misleading conclusions three prominent potential dangers or mistakes that might occur within an inappropriate application of analogies are:

Misleading assumptions

A first danger is that, by applying analogies, inherent misinterpretations and wrong assumptions within the underlying system might be directly transferred to the applied system of analogy. What if, for example, the focus lays on the potential linkage and associations between natural selection within evolution and the competitiveness of an organization? By taking Darwin's "survival of the fittest" *(Darwin, 1979)* as the starting point for an applied association to the organizational system, the inherent mistakes or wrong interpretations of Darwin's theory are taken over to the system of interest. If a system thinking point of view is going to be applied to the selection concept it is more a survival of those living organisms that are sufficiently adapted to its environment *(Bertalanffy, 1969; Riedl, 1975; Riedl, 1978; Maturana and Varela, 1992)*. This makes a big difference, so that it is no longer a question of attaining an optimum system's condition, but just a sufficient one. With regard to innovation this also explains way it is not always "the best" technical solution that succeeds on the market (for example the former success of the VHS video system over the 2000 system).

Superficial knowledge of system peculiarities

Inadequate knowledge about a system as the basis for further conclusions drawn for another system is certainly a significant source of errors. In order to apply analogies in a scientifically sound manner it is inappropriate to try to draw inferences based on a superficial knowledge of the system: As an example, for the development of a competitive strategy of the organization of biological systems might act as potential source, but only if a scientifically rigorous system understanding is given *(e.g., Schwaninger, 2005, 3)*; otherwise, as in the example of natural selection, strategies such as "only the strongest survive" result from a fragmentary system understanding.

Unilateral or isolated system consideration

Another danger within the application of analogies is a unilateral or isolated system perspective by reducing complex systems to too simplified cause–and-effect relations. Here, feedback relations and dynamic system developments over time cannot be taken into account and potential causes for change again might not have appropriate strategies and behavior as a result. Selection affects the whole living organism and consequently cannot be reduced to elements or subsystems of the organism. Therefore, within the development of biological systems and social systems such as organizations, the total utility and the total costs of the overall system are to be considered when talking about selection and competitive advantages.

To sum up, a fruitful analogical learning between natural evolution and human cultural systems can bring a better understanding of the general patterns of development of complex systems by identifying common underlying principles at a higher level of abstraction. On the other hand, the attempt to derive general valid laws (and consequently legitimate various kinds of behavioral

strategies) seems to be critical and in many instances wrong, as shown above. Especially in cases where analogies are drawn on the system of natural evolution, where even biologists advocate various meanings and underlying mechanisms of natural evolution *(e.g. Maturana and Varela, 1992; Wesson, 1991)*, the inappropriate knowledge of non-biologists can even lead to more confusion and populist results lacking a sound knowledge basis.

Conclusion

In this paper I tried to point out that the meaning of innovation and its implications have to be rethought if a systems thinking perspective is applied. The generation of innovation influences the generating organization and other organizations as well as its environment. Furthermore, the system's innovation behavior as the prevailing climate for or against the implementation of innovations has to be seen in a broader sense: It is not only about overcoming the hurdles of innovation by finding the right promoters, but instead also the positive side of poles of resistance towards innovation have to be seen in the right light. This means that resistance can help to avoid failure and even to generate more successful innovation.

With regard to the process of generating innovation, the role of analogies was discussed critically. It was shown that the application of analogies can be critical, especially when it is about social phenomena within dynamically changing complex systems. Here, an example was provided by biomimetics and with a specific example of analogy-based learning from Darwin's natural evolution for the development of organizations.

It has been the intention of this paper to point out that there is still a lack of systems thinking within innovation and creativity research. The vast majority of research lacks a holistic perspective. This seems to be critical with regard to the application of analogies, especially in such far-reaching cases such as analogies between patterns of behavior in the business world and the system of natural evolution. For the application of analogies it is crucial that this is done based on a well developed systems perspective, on sound logical foundation, and serious scientific rigor. For sound scientific research it is essential to do further research in fields such as analogies. The questions asked within this paper should provide a starting point for further research.

References

Capra, F. (1998). *Die Capra-Synthese*, Scherz Verlag, Bern, München, Wien.

Darwin, C. (1979). *The Origin of Species by Means of Natural Selection or The Preservation of Favoured Races in the Struggle for Life.* Avenel Books, New York.

Genter, D. and Markham, A.B. (1997). "Structure mapping in analogy and similarity," *American Psychologist*. 52(1):45-56.

Gentner, D., Holyoak, K.J. and Kokinov, B.K. (eds.) (2000). *The Analogical Mind: Perspectives from Cognitive Science.* MIT Press, Cambridge, Massachusetts.

Gemünden, H.G., and Walter, A. (1995). "Der Beziehungspromotor – Schlüsselperson für inter-organisationale Innovationsprozesse," *Zeitschrit für Betriebswirtschaft*. 65:971-986.

Gould, S.J. (2002). "The Spice of Life. An Interview with Stephen Jay Gould," in *On Creativity, Innovation, and Renewal*, (F. Hesselbein, and R. Johnston, eds.), Jossey-Bass, San Francisco:19-28.

Hauschildt J., and Chakrabarti A.K. (1988). "Arbeitsteilung im Innovationsmanagement,"

Zeitschrift Führung und Organisation. 6:378-388.
Hauschildt, J., and Gemünden, H.G. (eds.) (1999). *Promotoren. Champions der Innovation*, 2nd ed., Gabler, Wiesbaden.
Hauschild, J. (2004). *Innovationsmanagement*, Vahlen, Wiesbaden.
Heinrich, B. (1979). *Bumblebee Economics*, Harvard University Press, Cambridge et al.
Miller, A.S. (1990). *Gaia Connections – An Introduction to Ecology, Ecoethics, and Economics*, Rowman & Littlefield, Maryland.
Lovelock, J. (1991). *GAIA – the Practical Science of Planetary Medicine*, Gaia Books, London.
Maturana, H.R., and Varela, F.J. (1987). *Der Baum der Erkenntnis. Die biologischen Wurzeln menschlichen Erkennens*, Scherz Verlag, Bern et al.
Maturana/Varela (1992): *The Tree of Knowledge. The Biological Roots of Human Understanding*, Shambhala, Boston et al.
Mulej, M. (1995). "Different International Environments – Different Initiatives for Systems Thinking," *Wirtschaftskybernetik und Systemanalyse. Systemdenken und Globalisierung*. 18:377-380.
Mulej, M., Bastic, M., Belak, M., Knez-Riedl, J., Mulej, N., Pivka, M., Potocan, V., Rebernik, M. Ursic, D. and Zenko, Z. (2003). "Informal Systems Thinking versus Systems Theory," *Cybernetics and Systems* 34(2):71-92.
Mumford, M.D., and Porter, P.P. (1999). "Analogies," in *Encyclopedia of Creativity*, (M.A. Runco, and S.R. Pritzker, eds.), Vol. 2, Academic Press, San Diego et al.:71-77.
Nachtigall, W., and Blüchel, K.G. (2000). *Das große Buch der Bionik. Neue Technologien nach dem Vorbild der Natur*. Deutsche Verlags-Anstalt, Stuttgart München.
Riedl, R. (1975). *Die Ordnung des Lebendigen: Systembedingungen der Evolution*, Parey, Hamburg et al.
Riedl, R. (1978). *Order in living organisms: A systems analysis of evolution*, Wiley, New York.
Schumpeter, J.A. (1934). *The Theory of Economic Development*, Harvard University Press, Cambridge.
Schumpeter, J.A. (1934). *Capitalism, Socialism and Democracy*, Harper & Brothers, New York.
Schumpeter, J.A. (2005). *Kapitalismus, Sozialismus und Demokratie*, Francke, Tübingen.
Schwaninger, M., and Hamann, T.K. (2005). "Theory-Building with System Dynamics – Principles and Practices," discussion paper, no. 50, University of St. Gallen.
von Bertalanffy, L. (1969). *General Systems Theory. Foundations, Development, Applications*, George Braziller, New York.
Wesson, R. (1991). *Beyond Natural Selection*, MIT Press, Cambridge, Massachusetts.
Witte, E. (1973). *Organisation für Innovationsentscheidungen*, Schwartz, Göttingen.