P

Palliative Care

► Palliative Care and Hospice - Innovation at End of Life

Palliative Care and Hospice - Innovation at End of Life

Andreas Heller and Claudia Wenzel
University of Klagenfurt | Vienna Graz, Faculty of Interdisciplinary Studies (IFF Vienna)
Department of Palliative Care and Organisational Ethics, Vienna, Austria

Synonyms

End-of-Life Care; Hospice; Palliative Care; Terminal Care

Hospice and Palliative Care: Reactions in Modern Society

Until a few decades ago, people in Europe knew how to deal with the fateful destiny of death. Dying, death, and grief were all incorporated within the cycle of familial life. The social place for the beginning and the end of life was, in the broadest sense, the home (from the Greek *oikos*), the economy of the house, and the life – relationships within families and neighborhoods. Dealing with these crises of life was facilitated through natural, social, and traditional rituals and customs. People lived in a closely woven network of normative and ritualized customs and certainties. The menacing threats unleashed throughout life needed fencing in, taming, and domesticating: For centuries the ancestors had prayed, "From hunger, disease and war, plague, keep us, O Lord." As it was a relatively enclosed living environment, this construction of social reality was socially reinforced and confirmed. The religious concept of *heaven* (Gronemeyer 2012), arching almost self-evidently over individual and collective life, gave meaning and hope, as well as guidance in both good times and in bad, while the European Christian tradition provided the assurance that life does not end with the end of earthly existence. On the contrary, death and dying could be put in perspective with a glance at the sky – a view into the afterlife. Death, the care for the dead, and the survival of the mourners were in certain ways socially and ritually manageable.

Nowadays in Europe, this horizon of heavenly confidence is only observable in a religious minority. These religious certainties have lost much of their plausibility. Life has been radically secularized. How then should the modern, secular man handle his final frontier, and deal with his individual death? Should he just resign himself to fate? Or fight – planning and controlling his life, and taking his death in his own hands?

Today, the differentiation of society has given people radical freedom, releasing them from

E.G. Carayannis (ed.), *Encyclopedia of Creativity, Invention, Innovation, and Entrepreneurship*,
DOI 10.1007/978-1-4614-3858-8,

socialties, and designing their own paths for life and death. Within society's market of opportunities, in the juggle between powers and ideologies, people will be forced to choose how to lead their own individual lives. It only stands to reason that you will have to tailor the last coat (*pallium*) for yourself. Modern society has developed a new branch of care which offers possible options for "end of life" as part of its healthcare management. With advance directives by the patient, an individual picture will be built around one's death, along the question of what is desirable (or undesirable) for them at the end of life. A growing network of professionalized and highly specialized hospice and palliative care staff ensures that the end of life will correspond to that picture. What people do not want is to be alienated, lonely, in pain, suffering needlessly, attached to machines and deprived of freedom – just a part of a large, anonymous medical system. An individual death, which is peaceful, gentle, with a suitable preparedness "to go," has emerged as the normative leading model. This is a question of "leading a good death" – something that does not seem possible without outside assistance. It is about quality of life in death, which can apparently only be delivered by professionals. The idea is to have a choice between euthanasia, and hospice and palliative care, a reality already possible in some European countries (Netherlands, Belgium, Luxembourg, and partially in Switzerland).

Palliative Care is at the Root of the Hospice Movement

Palliative care originates from the International Hospice Movement, whose implementation in German-speaking countries began with a slight delay – arriving behind their English and American counterparts in the 1980s. Within the framework of international euthanasia societies (right-to-die-movement, DGHS = German Society for Humane Death) calling for dignified death, for the purposes of criminal law and legalizing active euthanasia, and in the rapid development of highly specialized and technology-dominated medicine, it seemed impossible to have a dignified death in a hospital: The image of a "cold lonely death in a broom closet" was overwhelming. This compelled a focus for the hospice movement, with the objective of being able to die in dignity and character by the people concerned.

The thanatology research, substantiated by the Swiss physician Elizabeth Kuebler-Ross living in America, has made it clear: Even patients who have exhausted all therapeutic options have needs for contact and relationships, want to be respected and not abased, and will experience different dimensions of affective-cognitive altercation to their impending death. They will require empathic communication and extensive attention as a basic human right. This ground-breaking work has spread throughout the world, though it had long been misunderstood in the sense of a linear step system.

The British doctor, carer, and social worker Cicely Saunders, who saw herself as a committed Christian, is regarded as a pioneer of modern hospice work and Palliative Care. She helped open St. Christopher's Hospice in London in 1967 – after a 20-year "pregnancy" with this idea of establishing a home for the dying. The terms *hospice (work)* and *palliative care* were always used interchangeably in their mother country of England.

The hospice concept continues to live on under the idea of European and ancient oriental hospitality. Human life, conceived as a pilgrimage, is reliant on hospitality to find its path and the destination. Hospices offer hospitality without ulterior motive – they provide unconditional interest in others and for the sake of others in their own right. These hospices are not just buildings, but rather they represent an approach and attitude to people and culture in society. In times of increasing commercialization and managerialism of health care (*It counts only if you can count it!*), the hospice currently provides a critically different option in offering care and attention to people in need via assistance and support for end-of-life requirements. First and foremost, the hospice movement is simply a citizens' movement, supported by volunteers – dedicated people

committed to the right and the opportunity for a good, dignified, and individualized death at the end of life, regardless of religion, race, gender, and financial status. In the German-speaking countries, palliative care (in Germany translated as *palliative medicine*) had eventually become marked by a profound process of professionalization, dominated by medicalization and institutionalization, and is still so influential today.

The term "palliative" is derived from the Latin *pallium* – meaning *coat*, and for a German-speaker, this would be described firstly as *enveloping*, or *wrapping*, in the sense of "caring protection." Etymologically, this Latin has roots in Indo-European: "Palliative" originates from "*pel*," meaning something akin to "fur" or "animal skin," and thus creating the meaning of "*pelte*," that is, defensive shield weapons for military use (cf. Morris 1997, cited by Clark and Seymour 1999). This dual aspect of "palliative" provides the affected persons to consider a more active role, and also highlights a "radical orientation for the affected persons" (Heller and Knipping 2007) by this approach in the modern health care system. The situation is always about an appropriate balance between too much and too little (invasive and therapeutic measures); it is about balancing the deceleration and acceleration of death, as described by the accepted WHO definition.

Conceptual Perspectives of Palliative Care

According to the globally accepted definition of the World Health Organization (WHO), palliative care is "*. . . an approach by which the quality of life of patients and their families will be improved if they are faced with a life-threatening illness and its associated problems. This shall be achieved through the prevention and relief of suffering by means of early identification, faultless assessment and treatment of pain and other physical, psychosocial and spiritual problems.*" (*WHO* 2002).

This definition includes the focused involvement of relatives and carers – that is, of persons affected by the suffering and of those connected to them – and of sharing in their concerns and care. Particular attention is given to the grief which sets in not only after death, but often also over the lengthy period of the diagnosis of a chronic disease, the multiple treatments until the death, and beyond. Although discussions concerning active euthanasia are currently in constant debate in many countries, the WHO definition is clearly limited in scope (Steffen-Bürgi 2007), though it is in the meanwhile seen as a normative guideline in the palliative care community.

In the revised version of the original definition dating back to 1990, there is a clear emphasis that the palliative care approach should come in very early on within the disease process – indeed, in parallel with other curative measures (WHO 2002). It remains open as to how these conceptual building blocks are to be implemented within different healthcare systems: thus, a variety of structures and forms have developed in Germany, Austria, and Switzerland over the past 20 years.

Specialist proposals resulted in an idea implemented through the development of primary care, and were mainly carried out by differentiated educational training and further education – from introductory training of volunteers to Master's courses in palliative care. (The first German-language training programs in palliative care were and are being offered by the IFF Faculty since 1999 as an interdisciplinary study in Vienna; other universities and colleges have followed suit according to this model, for example, Dresden, Freiburg, Salzburg, and St. Gallen). Another starting point is to look at the teething and interweaving of the development of individuals with the development of organizations; this is based on the view that a culture respecting death is always an *organizational* culture respecting death (Heller 2000a). Hospice work and palliative care are viewed as healthcare concepts focused on different emphases, especially in German-speaking countries.

Based on this understanding, palliative care will often be translated as "*Palliativversorgung*" in German, literally meaning *palliative provision or supply*. This simple translation does not imply

the rich diversity of the English term *care*. The term *care* is not without problems, since it insinuates a division of labor in which it treats one party as the subject of care and the other as an object of care. Therefore, it seems appropriate linguistically to use the Scandinavian-origin concept of *Umsorge*, literally meaning *nurture* or *care*, when speaking of hospice and palliative care-culture.

Palliative Care – A Matter of Age?

In the development of the hospice concept, the applicability of these conceptual elements for the chronically ill and elderly was never strictly excluded – indeed they were even decidedly highlighted by Cicely Saunders: *Terminal care should not be a facet of oncology, but of geriatric medicine, neurology, general practice and throughout medicine* (Saunders and Baines 1983: 2).

Nevertheless, the concept was based on and developed for terminally ill individuals with cancer. Academic palliative medicine has been largely rooted within the context of university-oncology. There are, however, many other groups of affected persons (only about 25 % of people in Central Europe die from a tumor-based disease – 75 % die from something else altogether). The focus of attention in the last few years has been, in particular, on the deaths of older men and women. There have been pilot projects trying to establish a hospice and palliative culture in nursing homes (Heller and Kittelberger 2010).

For several years now, there has been a systematic dedication in palliative care discourse at the international level, focusing on other target groups, including older persons.

Creating a close link between Gerontology and Palliative Care, Seymour and Hanson (2001: 102) write, *"Both attend to the pursuit of symptom control, while advising the judicious use of investigations and rejecting highly invasive and aggressive treatment modalities; both make the person and their family the unit of care, and have led the way in developing multidisciplinary and community-based models of care. In so doing they have developed parallel discourses of 'patient-centered' care, 'quality of life,' 'dignity,' and 'autonomy.' Further, both disciplines focus on areas – aging and cancer – that tend to provoke strong, even 'phobic' reactions from the public at large."*

Showing the way is a WHO publication entitled "Better Palliative Care for Older People" (Davies and Higginson 2004). It calls for public health strategies at the national level, with the objective of improving palliative care for older people. The term *palliative geriatrics* has been experimented with in German-speaking countries, and it certainly insinuates a "medicalizing tendency" (Clark 2002). It does not accommodate appropriately for either the practice or the daily lives of the elderly, or the interdisciplinary theoretical reflection of the concerns and care of the elderly.

The revolutionary notion in this approach of a new care-culture at the end of life views the individual person, as a woman, man, child, or adolescent within the context of their life-relationships. The "care unit" is, therefore, the social system, not just the individual.

According to the concepts and "discovery" of Cicely Saunders, people suffer *comprehensively* (her concept of "total pain") – that is, biopsychosocially and spiritually. This multidimensionality in the anthropology of "Caring" is indeed a revolution which is not only represented by conventional medicine. It makes interdisciplinary theory and practice essential – a logical consequence designed to complement interprofessionalism, especially for the so-called voluntary workers, the citizens (in a civic concept of civil society) who maintain the continuity of care.

The WHO definition of palliative care also stresses the spiritual needs of dying people. In recent years, this information has raised the awareness with regard to other non-medical dimensions of end-of-life care: Different approaches were discussed either via an interreligious approach (Heller 2000b), or based on the reinterpretation of the role of pastoral care and medicine. Similarly, the area of gender-sensitive hospice and palliative culture is becoming increasingly important (Reitinger and Sigrid 2010), as is the

realization that gender is also a significant dimension in the experience of suffering and pain (Lehner 2010).

Conclusion and Future Directions

Palliative care can be understood as an innovation within the healthcare system, both as an organizational and social innovation: interdisciplinary theory and practice are essential in the palliative care concept, while the "unit of care" is not just the individual, but the whole social system. The multidimensionality in the anthropology of "Caring" (on biopsychosocial and spiritual levels) can be seen as a revolutionary notion in this new care-culture, where the so-called voluntary workers and the "civil society" maintain the continuity of care.

Insofar the palliative care concept is also relevant for the knowledge society, because knowledge is not derived by the experts or professionals, but by the laymen. It is an anti-elitist approach, in which professionals act as supporters and facilitators, focusing on the needs of the persons concerned.

It must be noted that palliative care, within this multidimensional concept, has proven resistant to any form of machine-like image of man; it respects and recognizes people as subjects of their own lives, and strives for the required balance of autonomy and care needs in order to assist their social caregivers. It makes it necessary to reflect on the comprehensive work of the entire team, in both the outpatient and inpatient sectors, as well as being a part of a comprehensive care-culture within society.

Insofar that hospice work and palliative care have been forming a profound innovation within the healthcare system – and because this gap has been discovered and revealed as the "place for action" – the movement, as such, is guided by interdisciplinary, inter-professional, inter-organizational, interreligious, and intercultural principles.

Interestingly, hospice work is also an area where a new image of a "healthy death" (Wenzel 2012) can be created. Death is understood and attended to not as a result of disease or organ failure, but as part of a (spiritual) developmental process of a person, wherein pain may also be considered as an approach to a central dimension of life. "Healing" may then be possible, even if "curing" no longer is (Rakel and Weil 2003).

In this sense, hospice work and palliative care serve as a thorn within the medically and curatively oriented healthcare system, demanding a challenging discussion about death despite all the achievements of modern medicine not only for the dying individual, but equally for the relatives, carers, and professionals. Hospice work and palliative care do not only remind but also allow to trace (a society) back to the power of civil society, who is concerned to form and participate in new "cultures of care."

Cross-References

- ▶ Citizen Science in Health Domain
- ▶ Creativity and Age
- ▶ Healthcare and Innovation
- ▶ Interdisciplinary Research (Interdisciplinarity)
- ▶ Knowledge Society, Knowledge-Based Economy, and Innovation
- ▶ Transdisciplinary Research (Transdisciplinarity)

References

Clark D. Between hope and acceptance: the medicalisation of dying. BMJ. 2002;324:904–7.

Clark D, Seymour J. Reflections on palliative care. Buckingham: Open University Press; 1999.

Davies E, Higginson I. Better palliative care for older people? Copenhagen, Denmark: WHO Regional Office for Europe; 2004.

Gronemeyer R. Himmel, der. Sehnsucht nach einem verlorenen Ort. München: Pattloch; 2012.

Heller A. Die Einmaligkeit von Menschen verstehen und bis zuletzt bedienen. In: Heller A, Heimerl K, Husebø S, editors. Wenn nichts mehr zu machen ist, ist noch viel zu tun. Wie alte Menschen würdig sterben können. Freiburg im Breisgau: Lambertus; 2000a. p. 9–24.

Heller A, Kittelberger F. Hospizkompetenz und palliative care im Alter. Lambertus: Eine Einfer. Ei. Freiburg im Breisgau; 2010.

Heller A, Knipping C. Palliative care – Haltungen und Orientierungen. In: Knipping C, editor. Lehrbuch palliative care. Bern: Hans Huber; 2007. p. 39–48.

Heller B. Kulturen des Sterbens. Interreligiosität als Herausforderung für Palliative Care. In: Heller A, Heimerl K, Metz C, editors. Kultur des Sterbens. Bedingungen für das Lebensende gestalten. Freiburg im Breisgau: Lambertus; 2000b. p. 177–92.
Lehner E. Schmerz und Depression – die Bedeutung von Gender im Erleben von Leid. In: Reitinger E, Beyer S, editors. Geschlechtersensible Hospiz- und Palliativkultur in der Altenhilfe. Frankfurt am Main: Mabuse; 2010. p. 231–44.
Rakel D, Weil A. Philosophy of integrative medicine. In: Rakel D, editor. Integrative medicine. Philadelphia: Saunders; 2003. p. 3–10.
Reitinger E, Sigrid B. Gender-Care: verschiedene Sichtweisen für eine gelingende Integration. In: Reitinger E, Beyer S, editors. Geschlechtersensible Hospiz- und Palliativkultur in der Altenhilfe. Frankfurt am Main: Mabuse; 2010. p. 9–20.
Saunders C, Baines M. Living with dying: the management of terminal disease. Oxford: Oxford University Press; 1983.
Seymour JE, Hanson E. Palliative care and older people. In: Nolan M, Davies S, Grant G, editors. Working with older people and their families. Maidenhead/Philadelphia: Open University Press; 2001. p. 99–119.
Steffen-Bürgi B. Reflexionen zu ausgewählten Definitionen der Palliative Care. In: Knipping C, editor. Lehrbuch palliative care (2. durchg. u. korr Aufl.). Bern: Hans Huber; 2007. p. 30–8.
Wenzel, C. Heil Sterben. Zur Bedeutung alternativer Ansätze für eine ganzheitliche Begleitung Sterbender in Hospizarbeit und Palliative Care. Unveröffentlichte Dissertation zur Erlangung des akademischen Grades Doktorin der Philosophie an der Alpen-Adria Universität Klagenfurt I Wien I Graz, Fakultät für Interdisziplinäre Forschung und Fortbildung, Abteilung Palliative Care und Organisationsethik, Wien; 2012.
World Health Organization (WHO). National cancer control programmes. Policies and managerial guidelines. Geneva: World Health Organization; 2002.

Paradigm Shift

► Innovation and Entrepreneurship

Paradox of Agency

► Institutional Entrepreneurship

Park

► Clusters, Networks, and Entrepreneurship

Partial Retirement

► Cross-Retirement (Cross-Employed Cross-Retired) and Innovation

Partnerships and Entrepreneurship (Vol Entrepreneurship)

Delphine Gallaud
INRA CESAER (UMR 1041), Unité Mixte de Recherche INRA-Agrosup, Dijon Cedex, France

Synonyms

Networks interfirms cooperation; Strategic alliance

Introduction

Scholars have considered entrepreneurship only as a creation by an independent entrepreneur for a long time. However public policies reconsidered this view in the 1980s and encouraged the development of two new kinds of entrepreneurships: first, academic entrepreneurship during the 1990s, and second, corporate entrepreneurship (CE) in the following decade (Phan et al. 2009). At the end of the 1990s, public policies tried to improve the system of innovation and to speed up the conversion of fundamental research into commercial innovation. So, it encouraged the development of academic entrepreneurship (Nicolaou and Birley 2003). Academic entrepreneurship is a real breakdown with the traditional culture of university that focuses on the production of knowledge, and not on commercial

purposes. Corporate entrepreneurship includes various kinds of organizational practices that allow the firm to develop new innovations in internal such as in external ways (Narayanan et al. 2009). Internally, the parent company creates a structure that remains linked to her by property rights. Scholars call such situation as a "quasi-firm." Externally, the means that are used to develop CE are more varied. The parent firm can purchase license, buy other firms, create joint venture, or use any kind of strategic alliances between organizations.

Scholars have discussed for a long time about the definition of partnership. Partnership can take two main definitions. In the first and larger definition, partnership can be assimilated to interfirms cooperation. Economists use more the term of cooperation whereas managers use the notion of strategic alliance, but the meaning is quite similar. Interfirms cooperation is defined by the fact that two or more organizations, that remain legally independent, will coordinate their objectives and can share various means of production (human, financial know-how, etc.) to attain a common goal. But the organizations are still competitors in the end-product market (Imai and Itami 1984). Such situation is often qualified as "co-opetition" because firms use both competition and cooperation. Interfirms cooperation can take various concrete forms: subcontracting is the more frequent form, R&D contracts, agreement of joint R&D, joint venture, etc.

In the narrower second sense, partnership is defined only as the evolution in the interfirms relationships from subcontracting to more equal relationships. In fact, subcontracting is in general linked with unequal relationships between firms. With this evolution to more equality the subcontractor becomes co-owner of the product and it is encouraged to innovate to regularly improve the product. The narrower definition is less used because it is too restrictive. Afterward we will use the first definition.

These two definitions appeared following the rapid increase of partnerships in the 1980s, especially between competitors. This point challenged scholars about this kind of organization of interfirms relationships. Scholars developed two main theoretical approaches to explain this growth of partnerships. The two approaches are the neo-institutional economics (Williamson 1975, 1985) and the resource-based theory of the firm and the evolutionist approach (Wenerfelt 1984; Teece and Winter 1990).

The emergence of partnerships will be different in the three kinds of entrepreneurships. Entrepreneurs in start-ups can mobilize partnerships to develop their firm only when it has been created (after the registration of the status). Before the setup of the firm, we will qualify the interaction with other organization as a social network. But before this moment the firm cannot use an interorganizational link by definition.

CE is not systematically linked with partnerships. In the case of internal creation, in most of the cases, the parent company grants self-determination to the spin-out to allow it to explore any risky innovation projects, reducing the financial risk for the rest of the organization. The parent company keeps stakes in the capital of the spin-out but it can sell them if the project fails. The amount of the stakes will determine the degree of autonomy of the spin-out and its ability to conclude partnerships by itself. We can talk of partnerships only when they are concluded with another organization than the parent company. As far as external means are concerned, purchasing license and buying another firm are generally not considered as partnerships, however joint venture and strategic alliance can be qualified of partnerships.

Academic entrepreneurship is characterized by its origin. Academic entrepreneurs come from the research sector and they keep their relationships with their former colleague. So, the entrepreneur uses former networks that come from links into the academic world to be informed about new opportunities and to set up a new organization.

What are the relationships between partnerships and entrepreneurship? First, we will begin by the influence of partnership on the development of entrepreneurship, and in the second part, we will treat the opposite relationship.

The Influence of Partnership on Entrepreneurship

Setup of a new organization needs different stages: detection of opportunities, pre-setup, setup, and then very often a reorientation of the project to assure the sustainability of the project development. In fact, the difficulty for setup is to pass from one stage to another. The new firm manages to pass the different stages by recombining resources networks and partnerships or by creating new resources. Doing so, the firm recombines and makes evolves it links with other organizations. The entrepreneur mobilizes first its social network before building a professional inter-organizational network. So, time is important to understand the relationships between entrepreneurship and partnership.

Evolution of the Nature of the Links Between Organization and Its Environment

A new entrepreneur, in order to set up his firm has to mobilize a network that must be more dense and must include as many diversified resources as possible to favor the setup of the firm.

The pre-setup stage is associated with social network (including family members, friends, and neighborhood) (Schutjens and Stam 2003). Such network cannot be defined as partnership because partnership is only an inter-organizational linkage. And at the stage of pre-setup, the organization does not exist. But when the start-up is set up on the market it begins to establish such inter-organizational links. Then, the social network of the entrepreneur evolves toward partnership. New entrepreneurs can mobilize partnerships with customers and suppliers of the firm where they were employed before the setup of their own firm, or they can create totally new partnerships with new actors.

Public Policy Toward Start-Up: The Rise of Public-Private Partnerships (PPP) and Their Influence on Entrepreneurship

States used PPP since the nineteenth century to provide collective services when the budget necessary to fund them was too important for the state's budget. They were used especially to build large infrastructures or collective equipment (as hospital or schools). But PPP were used extensively only in the 1980s because public debts became too important in most of the European countries. PPP in the field of innovation obey the same logic as the one described above. For the traditional economic theory of innovation, knowledge produced during innovation activities is a public good characterized by non-rivality and non-excludability. These characteristics justify public intervention. So states must fund public research to sustain innovative activity (Arrow 1962). PPP includes devices to encourage entrepreneurship but they are not really efficient.

During the 1980s, countries that have used the model of furniture of knowledge by the state, via public organism of research, encountered many technological failures. In France, for example, the "plan calcul" failed. So the European Union, especially France, tried to correct their innovation policies. France had to face the lack of private R&D funded by firms. So, it tried to increase the investment in fundamental research, and PPP device was a means to increase private spending. France impulsed this device quite recently, during the 2000s. Many kinds of PPP relative to innovation are used such as RRIT, CNRT, CRITT or devices for human resources such as ERT, CIFRE, and corthechs. More recently, the device of pole of competitivité and the increase of the part played by the organism in charge of the transfer of technology was encouraged. PPP should also increase entrepreneurship especially the academic one. RRIT gathers all the actors of a technological field: public organism of research, firms, universities, school of engineers, professional organization of a field, and club of entrepreneurs. But in practice, in France, very few PPP include entrepreneurs. The evaluation of RRIT demonstrated that it was incumbent firms that have proposed projects of innovation and not start-up. But in fact, if PPP are not an efficient device to promote entrepreneurship it is because public policy dissociates innovative projects in partnerships and measure to sustain entrepreneurship (MESR 2009). And the point is validated even if the definition of the device of PPP allows gathering all the actors in the field,

including the entrepreneurs. The experience of other European countries gives the same mitigated result. For example, in Portugal, on 100 PPP studied, if almost all of them included associations of entrepreneurs of national regional or sectoral level, only eight PPP traduced on the development of innovative projects new entrepreneurs.

Influence of Entrepreneurship on the Kind of Partnerships Established

Difficulties for Start-up to Establish New Relationships

To introduce the point, we can remember that almost new entrepreneurs have a lot of difficulties to establish relationships with external organization and to create partnerships. Only 30% of new firms have two partnership relationships at the end of their first year of existence in addition to their standard relationships with suppliers and customers (Schutjens and Stam 2003). Besides, firms have many difficulties to stabilize these relationships during their first 3 years of ongoing business. Firms modify their networks during these years, diminishing their number to focus on the most important.

New technology based firms (NTBF) do not face such difficulties to establish new partnerships (Colombo et al. 2006). Seventy percent of the NTBF have at least one relationship during the first years. However the authors underline one difficulty; it seems that these firms face threshold effects, because of their lack of credibility in the marketplace. These firms are created around the innovative project and the competence relative to R&D and sometimes around the competence of development of products. They develop the competences of commercialization later. Throughout the first stage of development, they are too small to develop internally functions of commercialization and marketing. So they use partnerships with incumbent firms to access these competencies and the networks of distribution. NTBF are skilled in R&D and do not search in priority technological partnerships, but they can use partnerships in technology as complementary activities. For example, they can work as subcontractor on R&D contracts. In many cases, NTBF remain specialized on subcontracting of R&D and never develop capacities of production (Perez and Martinez Sanchez 2003). So commercial partnerships are dominant and represent 70% of the total of partnerships for NTBF versus 30% for technical partnerships. This kind of partnership remains important during the first 5 years of the firms and then they decline.

New firms have to establish partnerships, but in practice, many of them are reluctant to do so because they understand very well that such behavior is risky. NTBF that are highly skilled in scientific research are especially conscious of the risk to be expropriated from their knowledge by large incumbent firms. And their knowledge is a strategic asset for this kind of firm (Colombo et al. 2006). So, this behavior of large firm slows down the formation of NTBF's new partnerships till firms are able to protect their know-how, by patenting for example.

So, the most important difficulty for new firms will be to pass from the social to the professional network and to do so being able to protect their strategic asset.

Influence of the Entrepreneurs' Characteristics on the Kind of Partnerships: Difficulties to Diversify the Partnerships

Partnerships of New Independent Firms

Networks of new entrepreneurs evolve, after the start-up creation, from a social to a professional network (Schutjens and Stam 2003). The traits of the entrepreneurs influence the characteristics of partnerships they create. The question of the existence of a difference in the network of male and female entrepreneurs is still debated. Schutjens and Stam (2003) do not confirm the hypothesis, but Hoang and Antoncic (2003) found no difference between the two kinds of networks. Besides, characteristics of the firms influence its ability to establish partnerships. The intensity of R&D has an influence on partnerships. Firms that spend more in R&D establish more relationships than others. This relationship was regularly validated by econometrical studies since the 1980s. To own patents is a factor that influences positively the probability to establish relationships. Patents act as a signal of technological ability and help firms to create credibility to attract partners.

Small firms create fewer partnerships than bigger firms (Schutjens and Stam 2003). Firms in industry would create more partnerships than in services. But this result is validated only for technical partnerships (Colombo et al. 2006). Firms in service sector develop more commercial partnerships. At last, urban firms would have more partnerships than rural firms (Schutjens and Stam 2003).

Specificities of CE on the Kind of Partnerships Established

When a parent firm creates a spin-out, in fact the parent will serve as incubator for the spin-out. In function of the degree of autonomy that the parent let to the spin-out, the spin-out will have different possibilities to create partnerships (Parkhangras and Arenius 2003). These authors analyzed the creation of spin-out and identified three types of new firms. In the first group, the parent dissociates a subset of the company to explore risky technological project. It provides resources, such as financial or human or equipment, and then it only takes some stakes in the capital of the start-up. During all the exploration stages of the project, there are very few relationships between the parent company and the spin-out. This kind of spin-out never becomes an independent firm because if the project succeeds, the parent company buys all the stakes of the start-up and re integer it into the parent company. In this group, the spin-out has never enough time to establish partnerships with external organization.

In the second group, the parent company and the spin-out have the same technical basis. In most cases, the parent created the spin-out to provide it some special component that was difficult to purchase in the marketplace. R&D cooperation is strong in this group but with the parent company. As the time goes by, the marketplace can provide the components and purchasing on the market becomes less difficult. The parent firm can give autonomy to the spin-out and let him develop by himself. But then, the spin-out has to survive in the marketplace. As it is now an independent firm it can create the same partnerships as the one described in the first point. Spin-out of the third group is old and dissociated from the parent a long time ago. It is the case in more traditional sector, for example. At the beginning, the parent company plays the same part of incubator as described before; it shares resources with all the spin-outs. Then, the parent company generally refocuses on its core activity that is in most cases different from the core activity of the spin-outs. And at last, the spin-out becomes more and more a process developer. Links with the parent company loosen. Then the situation becomes the same as that described just before.

Academic Entrepreneurship and Partnership

Public policy tried to encourage academic entrepreneurship since the 1980s. Public policy maker's goal was to speed up the conversion of technological opportunities into commercial innovation. Literature on academic entrepreneurship takes up the literature about entrepreneurship and then brings to the fore the specificities of academic entrepreneurship. The literature underlines above all the lack of entrepreneurial culture in universities (Nicolaou and Birley 2003). Public policy tried to sustain the creation of start-up by academics, but in France, academic entrepreneurships are in fact in three fourth of cases scientific advisors in firms (MESR 2009). So scientific researchers do not often create their own start-up but let another person do it in most cases, such as an entrepreneur or an experienced manager.

Academic entrepreneurship can be associated to various degrees of implication of the scientific in the new firm. Scientific that give up their academic position are more implicated in the new firm and generally, this kind of firm grows faster. But, the academic diminishes his links with his prior university and at the same time takes the risk to slow down the speed of innovation in his start-up. Academic start-up generally maintains dense links with research and the scientific field. These traits are specific to the academic entrepreneurship, but contrary to more commercial start-up, academic entrepreneurs have often many difficulties to create market links with customers and suppliers (Perez and Martinez Sanchez 2003). But factors that slow down the establishment of networks can be the

problem of trust in relationships with large incumbent firms (Colombo et al. 2006). In fact, many academic start-ups, at the end of any years of ongoing business, do not still commercialize any products at all, but remain specialized as subcontractor of R&D contracts. That choice of specialization reduces their need to establish partnerships.

Besides, these firms have difficulties to diversify their partners. Spin-outs located in scientific parks, for example, have relationships with the university of the academic but not very dense and very few relationships with other external partners.

Conclusion and Future Directions

Partnerships have grown very quickly since the 1980s. But theoretical approach of partnerships is not still taking into account all the implications of that growth, as Chesbrough (2003) indicates with the debate around the model of open innovation. Scholars have conceptualized innovation activity as an internal activity of the firm for a long time. All the innovative activities from research to development of the products should be developed internally. From Chesbrough's point of view, this model is coherent when scholars think innovative knowledge as a strategic asset of the firm. The main drawback of this way of thinking is the risk of the "Not invented here" syndrome for the firm. In fact, many large firms do not detect very profitable innovative project because they lose their perception of the competitors' projects and the evolution of clients' needs, thinking all their projects internally. The model of open innovation is a way of thinking project development by screening all the competitors' projects and clients' need and by using all the external sources possible to innovate. It implies that if a firm cannot develop a part of a project internally it can buy the technology developed outside or establish partnerships to develop it. This model encourages firms to create a dense set of partnerships for each firm. But on the other hand, the model does not question the risk of partnerships especially for small SMEs. Open innovation could have a positive impact on the corporate entrepreneurship, because this model encourages firms to stay innovative by screening their environment to pick up future profitable projects. The best way to achieve this goal is to be able to create spin-out regularly.

As far as public policy is concerned, various points are at stake, which are as follows.

Firstly, public policy has difficulties to sustain entrepreneurship in efficient ways. This point was underlined analyzing the PPP's device, where entrepreneurship was dissociated from innovative projects. More generally, in France, public policy about entrepreneurship follows two main goals: on the one hand, to encourage the creation of start-up, especially in the more high-tech sector of the economy, but on the other hand, to encourage the creation of their own job by the entrepreneurs during the time of economic crisis. This second way often leads to the creation of small firms in the service sector that are less innovative than the first kind of firms. Public policy puts in place various devices for each kind of new firms, but these devices are often not linked to each other that increase the difficulty for new entrepreneurs to identify the measure.

Secondly, as far as academic entrepreneurship is concerned, the main problem is the link of the new firm to the marketplace. This kind of new firm is well connected to the scientific research but often lacks the production and commercial skills needed to allow the growth of the start-up. It can also be the case when these academic entrepreneurs try to sell their knowledge. One of the possible measures of public policy should be to incite more systematically the academic entrepreneur to create their firm with another entrepreneur specialized in management or commercialization.

At last, public policy often underestimates the risks associated with partnerships especially for SMEs; besides, for these kinds of firms, knowledge constitutes very often their unique strategic asset (Colombo et al. 2006). The problem is the protection of intellectual property for small firms and for start-ups that are generally small. In general, SMEs do not perceive the importance of the protection of their intellectual assets and actual means of protection that fit for the large firms but

not for SMEs. It is are case for patents, for example. Besides, European public policy develops at this time a pro-patent trend and does not create specific tools designed for SMEs.

Cross-References

- ▶ Academic Entrepreneurship
- ▶ Corporate Entrepreneurship
- ▶ Network and Entrepreneurship

References

Chesbrough H. Open innovation the new imperative for creating and profiting from technology. Boston: Harvard Business School Press; 2003. 231.
Colombo M, Grilli L, Piva E. In search of complementary assets: the determinants of alliance formation of high tech start-ups. Res Policy. 2006;35:1166–99.
Hoang H, Antoncic B. Network-based research in entrepreneurship: a critical review. J Bus Ventur. 2003; 18:165–87.
Imai H, Itami K. Interpenetration of organization and markets: Japan firms and markets in comparison with the US. Int J Ind Org. 1984;2:285–310.
MESR. Recherche et développement, innovation et partenariats. 2009. 90 p. http:www.media.enseignementsup-recherche.gouv.fr/. . ./SETTAR_2009_159899.pdf. Accessed June 2011.
Narayanan VK, Yang Y, Zahra X. Corporate venturing and value creation: a review and proposed framework. Res Policy. 2009;38(1):58–76.
Nicolaou N, Birley S. Academic networks in a trichotomous categorization of university spin-outs. J Bus Ventur. 2003;18:333–59.
Parkhangras A, Arenius P. From a corporate venture to an independent company a base for a taxonomy for corporate spin offs firms. Res Policy. 2003;32(3):463–81.
Perez M, Martinez Sanchez A. The development of university spin offs: early dynamics of technology transfer and networking. Technovation. 2003;23:823–31.
Phan P, Wright M, Ucbazarn D, Tan WL. Corporate entrepreneurship: current research and further direction. J Bus Ventur. 2009;24(3):197–205.
Schutjens V, Stam E. The evolution and nature of young firm's networks: a longitudinal perspective. Small Bus Econ. 2003;21:115–34.

Patent

- ▶ Patent System

Patent Exchange

- ▶ From Personal to Impersonal Exchange in Ideas

Patent Markets

- ▶ From Personal to Impersonal Exchange in Ideas

Patent System

Eskil Ullberg
Interdisciplinary Center for Experimental Science, George Mason University, Fairfax County, VA, USA

Synonyms

Intellectual property rights; IP system; Patent

Definition

The patent system grants and enforces temporal exclusive, transferrable, and licensable private rights on inventions – that provide solutions to (mostly) technical problems in the area of products and processes – in exchange for disclosure of the invention to the public at a level that can be understood by a person skilled in the art.

In order for an inventor to receive such a right, the invention typically has to meet three criteria: (1) The invention has to be new, i.e., after search there is no prior art found, (2) There is an inventive step or non-obviousness to the idea, i.e., new prior art is created that required a flash of genius or long toil thus advancing technical knowledge that others can build on (not so simple anyone could discover it), and (3) The idea has to be industrially applicable or useful – which excludes schemas as natural laws, mathematical formulas, and some military strategic

inventions – i.e., has a focus on industrial (economic) productivity. The ideas have to be technical in nature, except in the USA where nontechnical ideas also can be granted patents since the 1990s.

The patent system can be seen as operating under the principle of exchange between the inventor (or firm, university, research institution) and the state: An exclusive and tradable right is given for a limited time in exchange for disclosing to the public – teaching the world – about the invention, opening up for everyone to build on this previously private knowledge and invent further, thus creating *competition* in technical inventions. The system also establishes private and *tradable* property rights on new technology, creating the fundaments for a market in technical ideas. Such markets aught to allow, like all competitive markets, for specialization and specialization for increased productivity, wealth creation, and economic growth.

From an institutional perspective, the patent system is divided into two parts: the *patent office* and *patent enforcement* which sometimes is organized in specialized courts or specialized appeals courts. When granted, the patent is *presumed* valid and when enforced can be declared valid or be annulled. If patents are infringed by a third party, injunctions and stiff penalties can be deemed to the infringer based on the loss for the patent holder. However, an estimated 95 % of court cases are dropped prior to enforcement, resulting in a licensing agreement instead. The mechanism thus serves to give incentives for negotiation. It is important, for the well functioning of the patent systems, that procedures do give this incentive and not to rent seeking behavior.

The patent system was first established in Venice in 1474 and then spread via the Italian city states to first most European countries and in the nineteenth and twentieth centuries the industrialized countries of the world. Today, many emerging market countries are developing patent systems. See WTO/TRIPS agreement. The patent systems are national systems since about 150 years but remain essentially the same as the first system when it comes to the private, transferrable, and licensable right in exchange for disclosure.

Cross-References

▶ From Personal to Impersonal Exchange in Ideas

Patents

▶ Networks and Scientific Innovation

Patents and Entrepreneurship

Julien Pénin
University of Strasbourg – BETA (UMR 7522 CNRS-UdS), Strasbourg Cedex, France

Synonyms

Innovation policy; Intellectual property rights; Markets for technology; Open innovation; R&D collaboration

A patent gives to its owner an exclusive right on a product or process which is new, inventive, and has an industrial application (in the USA, this third criterion is broader in the sense that the invention needs not to have an industrial application but must merely be useful). From a legal point of view, a patent is a negative right. It gives the right to exclude but not necessarily to use an invention, if this use leads to infringe a right held by someone else. The maximum duration of the patent protection is 20 years after the first application (but a majority of patents does not last this long). Also, in most countries, patent applicants must provide a description of their invention which, 18 months after the first application, is made public (made available to everybody). The description must be sufficiently

clear and exhaustive in order to allow a person knowing the state of the art to reproduce the invention simply by reading the patent.

Originally, the patent system has been designed to provide entrepreneurs with incentives to invest in research and development (R&D) while, in the same time, ensuring a minimal level of knowledge diffusion (they are intended to solve the Arrow dilemma also called the incentives-diffusion dilemma, Arrow 1962). On the one hand, patents improve the level of appropriability over inventions (since they enable inventors to exclude imitators), which should increase incentives to invest in inventive activity. On the other hand, they participate to disseminate new knowledge since they are published. With respect to this double mission (provide entrepreneurs with incentives to both invent and disclose their invention), standard economic studies have thus been able to analyze the optimal length, width, and depth of the patent system (Scotchmer 2004).

Yet, in the last three decades, most economic studies (both theoretical and empirical) have questioned this traditional and simplistic view of the patent system (Levin et al. 1987; Mazzoleni and Nelson 1998; Jaffe 2000; Cohen et al. 2000). First, they show that patents are often not an efficient tool to prevent imitation because they are easily turned around and because they are often difficult to enforce in court (judicial trials are uncertain, long, and costly). Second, those studies also show that, for entrepreneurs, appropriation failure is usually not as important as considered by the classical view. Often, entrepreneurs can easily appropriate the value of their inventions without relying on patents (because, for instance, secrecy can be preserved, or the knowledge base is tacit, or technology is complex, i.e., not easy to reproduce). Third, recent economic studies stress that the production of innovation also faces a strong *coordination failure* and not only an *appropriation failure*. Innovation being a collective and interactive process, actors involved in this process need to interact, to collaborate, and to exchange knowledge. Yet, this collective process of knowledge production is often impeded by information imperfection and by the tacit dimension of the knowledge base. In sum, in a knowledge-based economy, the economic role of the patent system is likely to be more complex than what is presented by the traditional view (which considers only the role of patent as an instrument to exclude).

The following of this entry is divided in two parts. First, it describes the role of the patent system for entrepreneurs in a knowledge-based economy. In particular, it stresses that there is not one single role but a multiplicity of uses, according to the context. Second, it introduces the costs of patents for entrepreneurial activities and shows how patents may sometimes impede innovation.

The primary role of the patent system is not merely to restore appropriation but also to ensure the coordination of the innovation process. Patents are, in a sense, structuring elements of open innovation (Chesbrough 2003), because they cumulate two important properties: They both secure and disclose new knowledge. Those two properties imply that patents can improve both market and nonmarket coordination of the innovation process:

- *Market coordination*. Patents sustain the raise of markets for technology (Arora et al. 2001). Thanks to the patent system, innovative firms can directly specialize in knowledge production and sell their technologies to manufacturing firms via licensing agreements. They can also cross-license their patents, as it is typically observed in industries with complex technologies (in this second case, they barter their patents on markets for technologies) (Grindley and Teece 1997).
- *Nonmarket coordination*. Patents can also promote directly collaboration and knowledge exchange. First, because they signal relevant knowledge, which makes it easier for firms to find partners and to coordinate around a focal point, and second because, by securing technologies, they facilitate interfirm agreements. At the extreme, patents can also promote open-source type of knowledge production by preserving the openness of the knowledge base (Pénin and Wack 2008).

The role of the patent system for entrepreneurs is therefore very different from the image found in most economic textbooks. In a sense, patents may enable entrepreneurs to "include" other actors in the innovation process more than they "exclude." This is all the more relevant that the invention is emerging, i.e., knowledge is tacit, and opportunities (market and technological) are uncertain. In those emerging situations, it is indeed likely that needs of coordination overcome needs of exclusion, which may induce entrepreneurs to use the patent system essentially in order to smooth coordination problems and to foster open innovation.

This evolution of the utilization of the patent system also leads to rethink the rationales to patent for entrepreneurs. In most cases, firms apply for a patent not in order to effectively prevent imitation and to exclude competitors but, more subtly, in order to obtain access to technologies held by rival, to signal competencies, to trade technologies on a market, to prevent other firms to patent, etc. Entrepreneurs must therefore acknowledge and exploit this multiple and strategic role of the patent system.

In particular, patents play a critical role to sustain the emergence of entrepreneurial firms (start-up, spin-offs, etc.) (Arora and Merges 2004). Those "fabless" firms (they do not have tangible fabrication) produce only knowledge, which is intangible and, in the absence of patents, can be appropriated only to a limited extent. Hence, it is straightforward to understand why patents are often critical to the survival of these firms: They contribute to solve the Arrow paradox (1962). Without patents it is likely that they would find it difficult to make money out of their knowledge and hence could hardly raise venture capital funds. In sum, patents may sustain the emergence of a new industrial organization, with a vertical division of labor between fabless firms, which produce knowledge upstream, and then sell their technologies to manufacturing firms located downstream on the value chain. The cases of the pharmaceutical and of the electronic sectors are two famous examples of such a new industrial organization, which sees the emergence of fabless, entrepreneurial firms.

However, the role of the patent system is not homogeneous across sectors. It depends critically upon the characteristics of the firm and of the industry it belongs to, in particular the competitive intensity and the technological regime. The technological regime of a sector defines all the features of the basic technology which underlies a given industrial production and which affects the strategy of the actors. Its main dimensions are the degree of appropriability of the technology, its more or less modular nature, its degree of complexity, the existence of network effects, etc. Different technological regimes lead to largely different patenting strategies, and this explains the major differences observed in the use of patents in sectors such as pharmaceuticals, electronics, software, chemistry, etc. Due to heterogeneous technological regimes, actors of the innovation process in those sectors must rely on different patenting strategies.

For instance, the simple nature of the technology in pharmaceuticals, coupled with the specificity of the regime of appropriation in this sector (natural appropriation is weak but legal appropriation via patent is strong), explains why, in line with the traditional view of the patent system, pharmaceutical firms use patents primarily to exclude. Conversely, the complex, multicomponent nature of the technology in electronics explain why in this sector patents are used primarily in a defensive way, i.e., not to exclude imitators but to prevent being excluded, hence preserving firms' freedom to operate (Kingston 2001).

To sum up, in many industries patents are critical strategic instruments for entrepreneurs, which explain the burst of patent applications in fields such as life sciences and information technologies. Furthermore, the use of patents by entrepreneurs is not uniform and is not based solely on strategies of exclusion. It varies according to the context. The second part of this note aims now at exploring the problems that this new role of patents may raise.

Indeed, if the evolution in the utilization of the patent system can hardly be denied, a strategic use of patents can also entail serious costs and largely contribute to harm entrepreneurial

activities. Standard economic theory mostly stresses the monopoly deadweight loss generated by the patent system. Since patents give monopoly power to their owner, during their period of validity they inevitably contribute to raise prices above marginal cost, which generates a loss of surplus for society. This static loss is believed to be the price to pay in order to foster dynamic efficiency (to increase entrepreneurs' incentives to innovate). Within this view, patents have only positive effects in the long run. They can never damage the innovation process and undermine the dynamic evolution of the system.

Yet, when patents are used strategically, costs that stem from the patent system may be very different and, above all, may affect the innovation dynamics, i.e., may have negative consequences on the long run. First, patents can impede the dynamics of innovation by preventing entrepreneurs from accessing existing knowledge. Innovation proceeds indeed cumulatively, and today's inventions feed tomorrow's inventions (knowledge is both an input and an output of the innovation process). It is hence primarily important for entrepreneurs to have access to existing knowledge. Yet, patents give an element of control on this knowledge, thus potentially raising the cost to access it. In other words, the exclusive right conferred to inventors must not be too strong in order to preserve incentives to develop future innovations. This is all the more the case with respect to sequential innovations, in which a delicate balance must be found in order to preserve incentives to invest both in first- and second-generation innovations (Scotchmer 2004; Pénin and Wack 2008).

Second, the multiplication of overlapping patents in some sectors (this is especially true in sectors such as electronics where the technology is complex) may generate what authors have referred to as a "tragedy and the anticommons" (Heller and Eisenberg 1998) or a "patent thicket" (Shapiro 2000). The idea is that the proliferation of fragmented patents on a given technology makes it prohibitively costly for entrepreneurs to develop this technology (it is the well-known problem of multiple marginalization). Each patent owner having a right of veto over the overall technology, potential developers must bargain with all the stakeholders, which, at the end, may undermine the development of this technology. Patent thickets may hence deeply influence the choice of research programs and affect technology trajectories. They may lead to closing some technological fields which, from a pure research point of view, would be worthwhile pursuing, thus generating huge dynamic inefficiencies.

Third, the development and institutionalization of the patent system may give birth to perverse behaviors which, in the long run, could harm innovation (Jaffe and Lerner 2004). For instance, opportunistic strategies of "patent trolls" or "patent sharks" on markets for technology may radically decrease incentives of entrepreneurs and manufacturing companies to invest in R&D. Trolls indeed use the patent system for the sole purpose of litigation, without any intention to use the technology protected by the patent. The business model of those firms is therefore literally to be infringed (in order to earn money via litigation fees), thus hijacking radically the primarily role of the patent system (to prevent infringement). While perfectly legal, this strategic use of the patent system is likely to harm innovative activities by decreasing the incentives of genuine entrepreneurs to invest those activities.

Conclusion and Future Directions

In the knowledge-based economy, patents are important strategic tools for entrepreneurs who, in many innovative sectors, could hardly develop their activity without them. But in the same time, patents are also susceptible to seriously damage the pace of innovation, mainly by increasing the cost of accessing existing knowledge and technologies, which entrepreneurs need in order to develop tomorrow's technologies. The net benefit of the patent system for society is the outcome of those two counterbalancing forces.

This discussion on the role of the patent system is essential because it contributes to introducing new dimensions to comprehend the present debate on intellectual protection.

Yet, future research will have to complete it at least with respect to three issues:

First of all, future research will have to develop a framework to understand the determinants of firms' optimal patenting strategies. This note has suggested that the technological regime may be a central determinant of firms' choices. Yet, future work will have to go further and build a theoretical framework which, ideally, should be detailed and precise enough so that it can help with decision making for practitioners and policy makers.

A second important research track deals with the normative implications of the strategic use of patents. As soon as patents are also considered as tools of coordination or even of collaboration in a framework of open innovation, conducting a welfare analysis becomes very difficult. New threats may appear in the long run (anticommons, patent thickets), but also new benefits (markets for technology, open innovation). Hence, improving the normative understanding of patents is essential since proper public decisions can only be taken provided that we understand the likely consequences of each possible change.

A third "hot spot" with respect to the strategic use of patents deals with their financial value. In a knowledge-based economy, in which firms' main assets are their knowledge and technologies, it is highly important to be able to properly evaluate the financial potential of those technologies. Putting a value on a technology (patented or not) is critical, just to give a few examples, any time firms are trading technologies on a market (licensing in and out), are looking for capital, are buying other firms, are funding a joint venture, etc. It might therefore become primarily important to develop financial tools in order to assess the value of technologies and of patents.

Again, if, as assumed by the traditional framework, the role of a patent is just to secure a monopoly position, it is feasible (but not easy) to evaluate its financial value. Methods exist in order to forecast the size of the market and to compute the current value of future expected profits with more or less precision. But those methods neglect completely the strategic dimension of patents. And with respect to this issue, very little is known. For instance, how to evaluate with accuracy the financial value of a signal? A collaboration? Freedom to operate? Precise results and methods are still lacking.

Cross-References

- ▶ Academic Entrepreneurship
- ▶ Business Start-Up: From Emergence to Development
- ▶ Intellectual Property, Creative Industries, and Entrepreneurial Strategies
- ▶ Open Innovation and Entrepreneurship
- ▶ Start-Up

References

Arora A, Fosfuri A, Gambardella A. Markets for technology: the economics of innovation and corporate strategy. Cambridge: MIT press; Mass 2001.

Arora A, Merges R. Specialized supply firms, property rights and firm boundaries. Ind Corp Change. 2004;13:451–75.

Arrow KJ. Economic welfare and the allocation of resources for invention. In: The rate and direction of inventive activity: economic and social factors. Princeton: Princeton University Press; 1962. p. 609–25.

Chesbrough H. Open innovation: the new imperative for creating and profiting from technology. Boston: Harvard Business School Press; 2003.

Cohen WM, Nelson RR, Walsh J. Protecting their intellectual assets: appropriability conditions and why US manufacturing firms patent (or not). NBER working paper 7552, 2000.

Grindley P, Teece D. Managing intellectual capital: licensing and cross-licensing in semi-conductors and electronics. Calif Manage Rev. 1997;39:8–41.

Heller MA, Eisenberg RS. Can patents deter innovation? The anticommons in biomedical research. Science. 1998;280:698–701.

Jaffe A. The US patent system in transition: policy innovation and the innovation process. Res Policy. 2000;29:531–57.

Jaffe A, Lerner J. Innovation and its discontents: how our broken patent system is endangering innovation and progress, and what to do about it. Princeton: Princeton University Press; 2004.

Kingston W. Innovation needs patent reform. Res Policy. 2001;30:403–23.

Levin RC, Klevorick K, Nelson RR, Winter S. Appropriating the returns from industrial research and development. Brooking Pap Econ Activity. 1987;3:783–820.

Mazzoleni R, Nelson RR. The benefits and costs of strong patent protection: a contribution to the current debate. Res Policy. 1998;27:273–84.
Pénin J, Wack J-P. Research tool patents and free-libre biotechnology: a unified perspective. Res Policy. 2008;37(10):1909–21.
Scotchmer S. Innovation and incentives. Cambridge: MIT Press; 2004.
Shapiro C. Navigating the patent thicket: cross licenses, patent pools, and standard setting. Innov Policy Econ. 2000;1:119–50.

Pattern

► Models for Creative Inventions

Patterns of Technological Evolution

Boris Zlotin and Alla Zusman
Ideation International Inc., Farmington Hills, MI, USA

Synonyms

Engineering (engineered) systems; Laws; Tendencies; Trends

Introduction

One of the most valuable outcomes of G. Altshuller' s endeavor with the *Theory of Inventive Problem Solving* (TRIZ) was the discovery that technological systems evolved not randomly but rather following objective *Patterns of Technological Evolution*. These patterns could be identified based on the analysis of historical development of various technological systems; once having been documented, they could be purposefully used for further system development of systems avoiding numerous blind trials. Eventually, patterns of technological evolution provided a means for *TRIZ Forecasting* and *Directed Evolution*® (registered Trademark of Ideation International Inc.) – controlling the evolution of technological systems rather than merely solving ongoing problems.

The relatively wide practical application of the first *TRIZ knowledge base tool – 40 Inventive Principles* during the 1970s revealed the dramatic range of efficacy of the principles: while certain principles prompted fairly conventional solutions (such as principle 3, *local quality*), others yielded strong solutions with narrow application (32, *changing the color*) and some offered robust and widely applicable solutions that could be further refined and strengthened. In time it became clear that the most powerful Inventive Principles represented strong, recurrent Patterns of Technological Evolution (such as 15, *dynamicity*) or supported them (25, *self-service* as a way to increase *the ideality of a system*).

The first set of Patterns of Technological Evolution was distributed by Altshuller among TRIZ schools in the spring of 1975. This seven-page manuscript became the most valuable component of TRIZ and established the foundation for TRIZ as a science (Altshuller 1984).

The set of patterns included three groups named after the laws of theoretical mechanics as follows:

Group 1 – Statics – determines the beginning of a system's life cycle, including:

1. Completeness of an engineered system
2. Energy flow in an engineered system
3. Harmonization of the synchronization rhythms or parts in an engineered system

Group 2 – Kinematics – determines the general evolution of a system, including:

4. Increasing ideality of an engineered system
5. Nonuniform evolution of subsystems comprising an engineered system
6. Transition to the overall system

Group 3 – Dynamics – reflects evolution in contemporary conditions involving certain physical and technical factors, including:

7. Transition from macro- to micro-level in an engineered system
8. Increasing substance-field involvement

While continuing his work on the Patterns, Altshuller established several critical requirements a pattern of evolution should comply with: be ***informative*** (describing how systems

evolve), ***prognostic***, making it possible to predict the directions in which a given system would evolve; and ***instrumental***, helping to realize these directions and ultimately control the system's evolution.

In the fall of 1975, Boris Zlotin began teaching the first course on the Patterns of Technological Evolution to second-year students at the St. Petersburg People's University for Technical Innovation (SPUTI). During this and subsequent courses, Altshuller's patterns were presented in detail and illustrated with many examples, including military weaponry and even tactics and strategy. The active participation of many of the students (among whom were a number of talented engineers) prompted new ideas on the subject, encouraging attempts to further develop structure of the patterns via introducing *subpatterns* that were later called *Lines of Evolution* (sequences of actual steps within a particular Pattern). Although this structure was later criticized for its redundant complexity, the most important output of this attempt was the recognition that much room existed for enhancing and further developing the Patterns. Research efforts of various TRIZ theoreticians included studies in biological evolution (Vladimir Petrov and Boris Zlotin) as well as the evolution of science, art, language, social systems, etc.

In 1982, at the TRIZ conference in Petrozavodsk, Russia, Vladimir Petrov presented the forecasting of the evolution of electrical welding equipment (the first large-scale forecasting based on the Patterns of Technological Evolution). The second full-scale TRIZ forecasting was conducted by Boris Zlotin and Svetlana Visnepolschi for water pumps. The project also included a comparison of traditional forecasting and TRIZ forecasting methods.

Until 1985, the majority of studies on the Patterns were in technology, although examples of nontechnical applications were known and utilized in educational courses. Later, TRIZ forecasting projects included banks, mercantile and stock exchanges, educational systems, certain social systems, etc.

At the TRIZ conference in Novosibirsk, Russia, in 1984, several interesting works on the Patterns of Technological Evolution were presented, including:

- The "pulsing" model of evolution, by Yury Salamatov and Igor Kondrakov
- The increasing complexity and simplification of technological systems in the process of evolution, by Igor Vertkin
- Evolutionary patterns of methods and devices for curing broken extremities, by Nikolai Predein
- Two ways of increasing ideality of technological systems, by Boris Zlotin and Alla Zusman

By 1985, further development of the patterns of evolution became the primary focus of the Kishinev TRIZ School. The founders of this school changed the approach from working primarily with the patent library to studying the history of technology. The first results were published the same year (Altshuller et al. 1985), including:

- Upgrading the pattern of *coordination of rhythms* to *matching-mismatching of all technological system parameters*
- Introducing two new patterns: *reduction in human involvement* and *increasing dynamism and controllability*
- A new structure for the patterns, including multiple Lines of Evolution

In addition, several of Altshuller's patterns were omitted from the new system, in particular:

- Two patterns from the group Statics (*completeness* and *energy flow* in technological systems), as they represented the conditions for a system's emergence rather than its evolution. Moreover, certain cases were found that contradicted these patterns.
- The pattern *increasing substance-field involvement* related more to system models than to the evolution of real technological systems. However, the essence of the pattern related to the actual utilized field evolution, which was included as a line of evolution within the pattern *transition to the micro-level*.

Eventually, the following system of patterns was suggested (Zlotin and Zusman 1989):

- Stages of evolution (infancy, growth, maturity, and decline)
- Evolution toward increased ideality

- Nonuniform development of system elements
- Evolution toward increased dynamism and controllability
- Evolution toward increased complexity followed by simplification
- Evolution with matching and mismatching elements
- Evolution toward micro/multi-levels and the increased use of fields
- Evolution toward decreased human involvement
- TRIZ and elements of creative education

Given the above, it can be said that over the last 65 years TRIZ has grown from a problem-solving methodology to a ***science of technological evolution***, with the Patterns of Evolution at its core. At the same time, all known patterns are empirical in nature and therefore can describe the main direction ("what") of a system and its actual evolution ("how") but lack the "why" – that is, an explanation of the origin and driving forces of technological evolution. Obviously, finding answers to these questions is critical for revealing and structuring the patterns and for TRIZ becoming widely recognized as a science.

Another important aspect of converting knowledge about evolutionary patterns into a real science is consensus with regard to the main definitions and assumptions. To date, TRIZ literature refers to laws of evolution, patterns of evolution, trends of evolution, and lines of evolution. Different translations from Russian into English and other languages also contribute to the confusion.

Definitions and Assumptions

Definitions

The first attempt to clarify definitions for English terms for the main TRIZ elements related to technological evolution was made as follows (TRIZ in Progress 1999):

An *evolutionary trend* is a sequence of events directly and/or indirectly connected through cause-effect relationships. Each event in the chain (alone or together with the others) leads to the next one and thus increases the probability of its emergence. A trend may represent a limited (specific) model of an evolutionary process that describes its specific feature(s). Examples of trends in social life, technology, science, fashion, art, etc. are well known.

Examples.

- *Growth of "high-tech" technologies*
- *Increasing attention to the environment*
- *Increasing utilization of synthetic materials*

A *Pattern of Evolution* represents a strong, historically recurring tendency in the development of technological systems.

Examples.

- *Evolution toward decreased human involvement*
- *Evolution toward increased dynamism and controllability*
- *Evolution toward micro-levels and the increased use of fields*

A *Line of Evolution* reflects the historical sequence of changes that a technological system undergoes during its evolution.

Example. *A multistep transition that includes the following steps:*

1. *Use of a permanent field*
2. *Transition to a pulsed field*
3. *Utilizing a pulsed field with matched frequency*

While a trend might be a short-lived event (e.g., certain styles in consumer products) patterns and lines represent the strongest long-term (often permanent) trends. In other words, a pattern of evolution addresses *what* exactly will happen as a result of evolution (e.g., increasing dynamism); a line of evolution shows *how* this goal will be accomplished (step-by-step).

Selected Assumptions

Evolution at the Expense of Resources

A system's evolution proceeds via the consumption of various *resources* existing in the system itself, its neighboring systems, and/or the system environment. Each evolutionary step generates

new resources that can be used to further develop the given system as well as other systems. However, negative resources that can cause undesirable effects might also result from the evolutionary process (Zlotin and Zusman 2001).

Short-Versus Long-Term Forecasting

A system's short-term evolution (improvement) depends primarily on the resources inherent in the system. Long-term development, including next-generation systems, breakthroughs, etc., depends on the evolution of the overall technology and/or market rather than on the particulars and resources of the given system.

Limited Number of Ways to Perform a Function

A function can be realized in a limited number of distinguishable ways based on the utilization of available resources. New types of resources might arrive as a result of a discovery.

Formation of Specialized Lines of Evolution

For a specific system or for systems of a certain type (e.g., measurement and control systems, milling systems, software, etc.) a set of specialized lines of evolution can be developed that will reflect and take into consideration the main particulars of that system or system type.

Driving Forces of Technological Evolution

Any TRIZ specialist practicing TRIZ forecasting or Directed Evolution for products and/or technologies would eventually realize that to make a reliable forecast for a particular subsystem (such as a car door or cleaning products) one must first understand where the higher-level system is headed (the automobile for the car door, the home for the cleaning products). Furthermore, the design of the car or home might be governed by certain environmental and/or social regulations. At the same time, requirements imposed by a higher-level system are always dominant and "force" the subordinate system (or subsystem) to evolve accordingly (with the "permission" from technology, of course). Indeed, technological evolution is not an isolated process but rather is an aspect of the more general evolution of society; moreover, the evolving world resembles a Russian nested doll (*matreshka*) with multiple evolution processes of different scale taking place both independently and interdependently.

Given the above, it can be suggested that the evolutionary trends/patterns of the higher level serve as evolutionary driving forces of the lower levels. This suggestion can explain why the Patterns of Technological Evolution are so strong and reliable. For example, the pattern *increasing dynamism* is strong because increased dynamism means more flexibility – an important performance feature that in turn provides more convenience for the user. This pattern also could be considered long-term (or even permanent or "eternal") because convenience is an "eternal" user's benefit.

Orientation according to the main user benefits can help create a certain structure for evolutionary patterns. These main user benefits could be listed as follows (in no particular order):

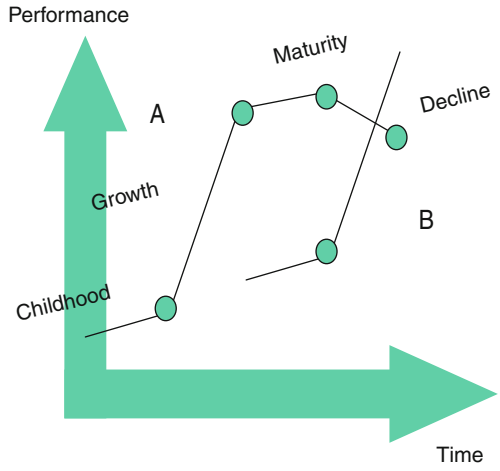
- System performance (i.e., providing a certain positive function)
- Cost
- Quality (reliability, absence or limited number of drawbacks and side effects)
- Safety/security
- Fun associated with the owning and/or utilization of the given system

It seems reasonable to suggest that these main requirements serve as a natural selection mechanism for all man-made systems.

General Patterns of Technological Evolution

Stages of Evolution

In the process of evolution, technological systems evolve along S-curve with specific definite stages as shown below (Fig. 1).



Patterns of Technological Evolution, Fig. 1 Stages of evolution (Altshuller 1984)

Stage 1 (Childhood) – A new system A appears due to a high-level invention and begins slow development.

Stage 2 (Growth) – Begins when society recognizes the value of the new system.

Stage 3 (Maturity) – Begins when the resources of the system's original concept is mostly exhausted.

Stage 4 (Decline) – Begins when a new system B or next system generation emerges to replace the existing one.

Depending on the stage, different recommendations on further development of the given system are recommended (Altshuller 1984, Zlotin and Zusman 2001).

Later, an extended and more detail S-curve was introduced (Fig. 2):

Under this approach, two additional stages have been indicated:

Stage 0 – A system does not yet exists but important conditions for its emergence are developing.

Stage 5 – Begins if the new system does not completely replace the existing system, which still has limited application.

In addition, stages 1–4 have been divided into three substages (beginning, middle, and end) as the system behavior could be very different during different parts of a stage.

Selected lines for this pattern include for each stage:

- Typical objectives
- Typical mistakes
- Typical features

Evolution Toward Increased Ideality

Technological systems evolve in the direction of increasing *ideality*. Ideality for a given system can be defined as the ratio of the sum of its useful features (benefits) to the sum of harmful (or undesired) factors. Therefore, system's ideality can be increased by increasing its useful features, reducing the harmful ones, or both.

Typical lines for this pattern include:

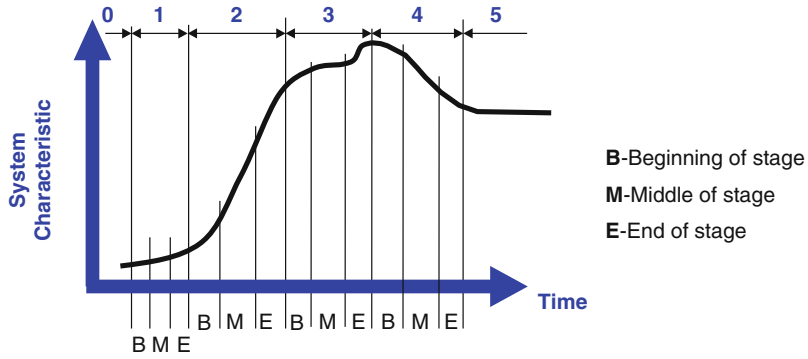
- Increasing system benefits
- Reducing harmful factors
- Increased involvement of *resources*

Given the above, there are several possible general ways to gradually increase Ideality:

1. Increase the number of useful functions/features, including:
   - Absorbing the useful functions of other systems nearby the given system, or of the environment
   - Inventing new useful functions
2. Improve the quality (and other parameters) of the useful functions
3. Reduce the number of harmful factors, including:
   - Eliminating/preventing harmful factors
   - Diverting harmful factors to other systems or parts where the harmful influence is less critical
   - Finding useful applications for harmful factors
4. Reduce the magnitude of harmful parameters
5. Combine the above actions to ensure a higher ratio

Non-uniform Development of System Elements

In the process of evolution, different components of a technological system usually evolve according to their own schedule. As a result, they might reach their inherent limits at different times, causing *contradictions* preventing further evolution of the given direction.



Patterns of Technological Evolution, Fig. 2 Extended S-curve (Zlotin and Zusman 2001)

A component that reaches its limit first is usually "holding back" the overall system development. To ensure further system development, the component(s) holding the system back have to be identified and contradictions limiting further evolution have to be removed (resolved).

Evolution Toward Increased Dynamism and Controllability

In the process of evolution, technological systems become more dynamic and allow better handling (higher controllability), that is, become more adaptive to contradictory requirements and to the environment.

Increased dynamism and controllability allows the system to conserve high ideality in changing conditions. An airplane wing, a car seat, a bed, and many other things became changeable, flexible, and thus much more comfortable.

Typical lines for this pattern include:

- Transition to multifunctional performance
- Increasing degree of freedom

System's dynamism could be increased via:

- Decreasing the degree of stability
- Transition from a stationary to a mobile condition
- Dividing into mobile parts
- Introducing a mobile object
- Applying different physical and chemical effects

System's controllability could be increased via introducing:

- Control field
- Controllable additive
- Controllable antiprocess
- Self-control of the system
- Negative or positive feedback

Evolution Toward Increased Complexity Followed by Simplification (Reduction)

In the process of evolution, technological systems tend to develop first toward increased quantity and quality of system functions (function deployment) resulting in increased system complexity. After improved functionality is achieved, the system developers try to simplify the system (reduction) maintaining the achieved functionality.

In a particular system evolution, the stages of deployment and simplification take place in turn forming cycles (each cycle includes one deployment and one simplification). They also can partially overlap. For example, while the overall system is in the simplification process, its subsystems can still be in deployment, and vice versa.

Typical lines for these patterns include:

- Transition to mono-bi-poly-system
- Idealization

There are several scenarios for system deployment:

- Introducing new subsystems extending functional capabilities
- Segmentation (dividing the system into parts with different functions assigned)
- Integration, including duplication, multiplication, or Integration "up" (the given system is included into a higher-level system as a part together with some others)

- Hybridization (combining systems with similar functions implementing different principle of operation)

For simplification step, one can use the following selected recommendations (other techniques known as *trimming* and *idealization* could be also utilized):

- Excluding duplicate elements
- Using more highly integrated subsystems
- Excluding auxiliary functions
- Introducing self-service
- Simplification through total replacement (changing principle of operation of subsystems)

Evolution with Matching and Mismatching Elements

In the process of evolution, systems' elements and parameters are undergoing a number of steps involving matching and/or mismatching to improve performance or to compensate for undesired effects.

The process of matching starts from the beginning of the system's existence when necessary system elements are selected and combined in one system. Besides providing minimal performance, these elements have to be compatible. Compatibility is very important for the overall performance; that is why sometimes the elements with the best individual performance might not be the best from the overall system performance point of view.

Matching/mismatching could be applied to the following elements:

- System structure
- Materials
- Functioning
- Parameters

One of the typical lines for this pattern is shown below. These steps constitute a cycle that can be repeated as the system evolves.

Step 1: From unmatched elements to matched ones

In the beginning of a system evolution, the system could be assembled from subsystems and parts that are available and have never worked together before. Next, various adjustments are made to improve their compatibility.

Example. *The first automobile was assembled from a horse carriage, an engine, and other elements. Later, these elements were modified to work in a new environment.*

Step 2: Intentionally mismatched systems

In many situations, the system elements can be intentionally mismatched to obtain new useful features or avoid negative effects.

Example. *Automobile front wheels are made slightly nonparallel to ensure that after making a turn a steering wheel automatically returns to the straight position.*

Step 3: Dynamic matching-mismatching

Often a system should work in changing (dynamic) conditions. In this case, the system would alternate its state to match those conditions.

Example. *An airplane wings change its shape to match higher speed and goes back when the speed drops.*

Evolution Toward Micro/Multi-levels and Increased Use of Fields

In the process of evolution, systems tend to utilize multiple systemic (structural) levels available in the given system, capitalize on their properties and increase use of *fields* and various physical states.

Typical lines for this pattern are shown below:

1. Utilization of deeper structural levels or combinations of these levels, using:
   - System made of elements with specific shapes
   - Poly-system made of elements with simple shapes
   - Poly-system of small elements (powder, microspheres, granules, drops, etc.)
   - Effects associated with substance structure (super-molecular or crystal level)
   - Molecular phenomena
   - Atomic phenomena
   - Field actions instead of substances

Patterns of Technological Evolution, Table 1 Utilization of fields and/or combinations of fields (Table 1, Zlotin 2001)

Basic field	Specific fields	Special corresponding substance(s)
Mechanical	Gravity	
	Pressure	
	Shocks, vibration	
	Explosion	Explosives
	Acoustic waves	
Thermal	Heating/cooling Aggregate state transformation	Water-ice-vapor
		Bimetals
		Shape-memory effect materials
Chemical		Catalysts, inhibitors
Electrical	Electrical charges	Dielectric materials
	Electrical current	Conductive materials
Magnetic	Electrical current	Conductive materials
	Permanent magnetic field	Magnetic materials, magnets, ferromagnetic particles

2. Utilization of the following fields and/or combinations of fields (Table 1, Zlotin 2001):

Evolution Toward Decreased Human Involvement

In the process of evolution of various systems, gradual reduction of human involvement has been taking place, increasing the level of systems automation until the system becomes completely manless.

Typical lines for this pattern include reducing human involvement in:

1. Operation (execution), using:
   - Simple mechanical tools instead of hands, teeth, etc.
   - Mechanical energy transformers and accumulators for human power, such as levers, gears, jacks, bow, springs, sling, etc.
   - Nonhuman energy sources (animals, wind, water, steam, chemical power, electrical power, nuclear power, etc.)
2. Process control (management), using:
   - Tools to control system functioning, such as rudders, steering wheels, airfoils, guides, etc.
   - Special devices to transform control commands, such as amplifiers, reducers, filters, rectifiers, stabilizers, modulators/demodulators, etc.
   - Devices to produce control commands, such as cams, gyroscopes, punched cards, etc.
3. Decision making, using:
   - Various sensors (mechanical, thermal, chemical, electrical, magnet, etc.) instead of human senses as information tools
   - Devices for processing information – that is, analyzing, summarizing, measuring, verifying, etc.
   - Devices to make decisions based on information analysis

Conclusion and Further Directions

1. Over the last 65 years, TRIZ has grown from a problem-solving methodology into the ***science of technological evolution***, with the Patterns of Evolution as its core. At the same time, we know that all known Patterns are empirical in nature and therefore can describe the main direction ("what") of a system and its actual evolution ("how") but lack the "why" – that is, an explanation of the origin and driving forces of technological evolution.
2. Technological evolution is not an isolated process but rather is an aspect of the more general evolution of society; higher-level evolutionary trends/patterns serve as the driving force for evolution at the lower level. Because higher-level super-systems include human needs and social requirements, Patterns of Technological Evolution are enforced by the general demand and expectation of customers.
3. Using knowledge of the Patterns of Technological Evolution in conjunction with analytical methods and other instruments provides the following benefits:
   - Ensuring a substantial advantage over competition

- Avoiding costly and often irreparable strategic mistakes in product development and marketing.

4. In spite of over 30 years of history, Patterns of Technological Evolution is a rather new area of research. Further directions could be:
   - Finding an optimal structure of exiting patterns
   - Development of additional lines of evolution, including specialized lines
   - Obtaining actual statistical data on known patterns of evolution
   - Extending the concept of patterns of evolution into other areas, including nontechnical areas, like evolution of arts, social evolution, etc.

Cross-References

- ▶ Creativity and Innovation: What Is the Difference?
- ▶ Directed Evolution® Technology
- ▶ Intellectual Property, Creative Industries, and Entrepreneurial Strategies
- ▶ Invention and Innovation as Creative Problem-Solving Activities
- ▶ Inventive Problem Solving (TRIZ), Theory
- ▶ Inventive Resources

References

Altshuller G. Creativity as an exact science. Moscow: Sovetskoe Radio Publishing House; 1979 (In Russian; English edition from Gordon and Breach, Science Publishers, Inc., 1984).

Altshuller G, Zlotin B, Philatov V. The profession of searching for new ideas. Kishinev: Kartya Moldovenyaska Publishing House; 1985.

Altshuller G, Zlotin B, Zusman A, Philatov V. Searching for new ideas: from insight to methodology; the theory and practice of inventive problem solving. Kishinev: Kartya Moldovenyaska Publishing House; 1989.

Mann DL. Hands-on systematic innovation. Ieper: Creax Press; 2002.

TRIZ in progress. Transactions of the Ideation research Group. Southfield: Ideation International Inc.; 1999.

Zlotin B, Zusman A. Patterns of technological evolution. Kishinev: STC Progress in association with Kartya Moldovenyaska Publishing House; 1989.

Zlotin B, Zusman A. Directed evolution: philosophy, theory and practice. Southfield: Ideation International Inc.; 2001.

Zlotin B, Zusman A. Patterns of evolution: recent findings on structure and origin. Altshuller's TRIZ Institute Conference TRIZCON 2006, Milwaukee, April 29 to May 2, 2006.

Perceptron-Imagitron Pairs

▶ Creativity Machine® Paradigm

Performance Creativity

▶ Creativity in Music Teaching and Learning

Periodic Table of Elements

▶ Creativity in Puzzles, Inventions, and Designs: Sudden Mental Insight Phenomenon

Personality

▶ Four Ps of Creativity and Recent Updates

Personality/Traits Explanations

▶ Individual Determinants of Entrepreneurship

Personalized Medicine

▶ Translational Medicine and the Transformation of the Drug Development Process

Persuasion

► Four Ps of Creativity and Recent Updates

Petri Nets

► State Space Paradox of Computational Research in Creativity

Pharmaceutical Innovation

► Translational Medicine and the Transformation of the Drug Development Process

Pharmaceutical Products

► Translational Medicine and the Transformation of the Drug Development Process

Phased Retirement

► Cross-Retirement (Cross-Employed Cross-Retired) and Innovation

Philosophy of Governance

► Epistemic Governance and Epistemic Innovation Policy

Pictures

► Speaking Pictures: Innovation in Fine Arts

Picturing

► Imagination

Pioneer

► Self-made Man

Planned Economy and Entrepreneurial Function

Jesus Huerta de Soto
Catedrático de Economía Política, Universidad Rey Juan Carlos, Madrid, Spain

Synonyms

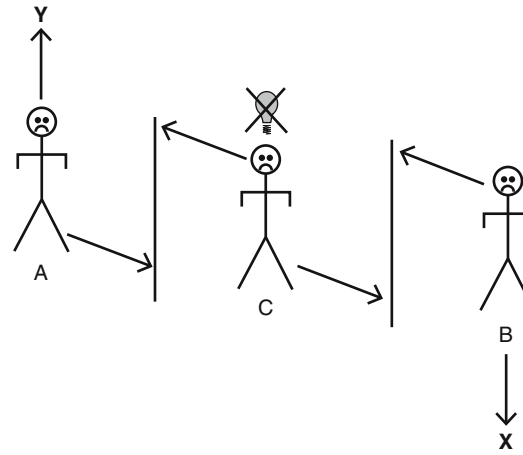
Entrepreneurial creativity; Entrepreneurial knowledge; Government commands; Institutional coercion

Entrepreneurship is a key concept for any definition of the planned economy. In fact, the planned economy or "socialism" could be defined as any *system of institutionalized aggression against the free practice of entrepreneurship* (Huerta de Soto 2010, p. 49). *Aggression* or *coercion* must be understood to mean any physical violence or threat of physical violence which is originated toward and performed on an individual by another human being or group of human beings. As a consequence of this coercion, the individual, who would have otherwise freely carried out his or her entrepreneurship, is, in order to avoid a greater evil, forced to act differently to the way he/she would have acted under other circumstances, thus modifying his or her behavior and adapting it to meet the ends of the person or persons who are coercing him or her. Aggression, thus defined, is considered to be the antihuman action par excellence. This is so because coercion prevents a person from freely carrying out his or

her entrepreneurship, that is, from seeking the objectives he/she has set using the means which, according to his or her information and to the best of his or her knowledge, he/she believes or considers to be accessible to him or her for reaching these objectives. Aggression is, therefore, an evil because it prevents the human being from carrying out the activity which is most characteristic of him or her and which essentially and most intimately corresponds to him or her (Hayek 1959, pp. 20–21; Rothbard 1970, pp. 9–10).

There are two types of aggression: systematic or institutionalized and nonsystematic or noninstitutionalized. The latter type of coercion, which is, by nature, dispersed, arbitrary, and more unpredictable, affects the execution of entrepreneurship to the extent that the individual considers there to be a greater or lesser probability that, in the context of a specific action, force will be used upon him or her by a third party, who may even appropriate the results of his or her entrepreneurial creativity. Although nonsystematic outbreaks of aggression are more or less serious, depending on the circumstances, institutionalized or systematic aggression is far more serious as regards coordinated human interaction. This type of aggression constitutes the essence of the given definition of socialism (Hoppe 1989, p. 2). In fact, institutionalized coercion is characterized by being highly predictable, repetitive, methodical, and organized. The main consequence of this systematic aggression against entrepreneurship is to make largely impossible and perversely divert the execution of entrepreneurship in all the areas of society where the said aggression is effective. Figure 1 presents the typical situation resulting from the systematic practice of coercion.

In Fig. 1, it may be assumed that, in an organized and systematic way, the free human action of C in relation to A and B in a specific area of life in society is prevented by coercion. This is represented by the lines which separate C from A and B. As a consequence, it is not possible, as systematic coercion prevents it by the threat of serious evils, for C to discover and take advantage of the profit opportunity which he would have if he could interact freely with B and



Planned Economy and Entrepreneurial Function, Fig. 1 Human action and coercion (Source: Author)

with A. It is very important to clearly understand that the aggression does not only prevent him from taking advantage of the profit opportunity, but also prevents the discovery of this opportunity. The possibility of obtaining gains or profits acts as an incentive to the discovery of these opportunities. Therefore, if a determined area of life in society is restricted by systematic coercion, the actors tend to adapt to the said situation, they take it for granted, and therefore, do not even create, discover, or become aware of the opportunities which are latent. This situation is presented in the figure by crossing out the light bulb which indicates the creative act of pure entrepreneurial discovery.

If the aggression falls systematically upon one social area and, as a consequence, entrepreneurship cannot be carried out in that area, none of the other typical effects of the pure entrepreneurial act will take place. In fact, in the first place, new information will not be created, nor will it be transmitted from actor to actor. Second, which is a cause for even more concern, the adjustment necessary in cases of a lack of social coordination will not occur. As the discovery of opportunities for profit is not permitted, there will be no incentive for the actors to become aware of situations of lack of adjustment or coordination which arise. In short, information will not be created, it will not be transmitted from one agent to another, and

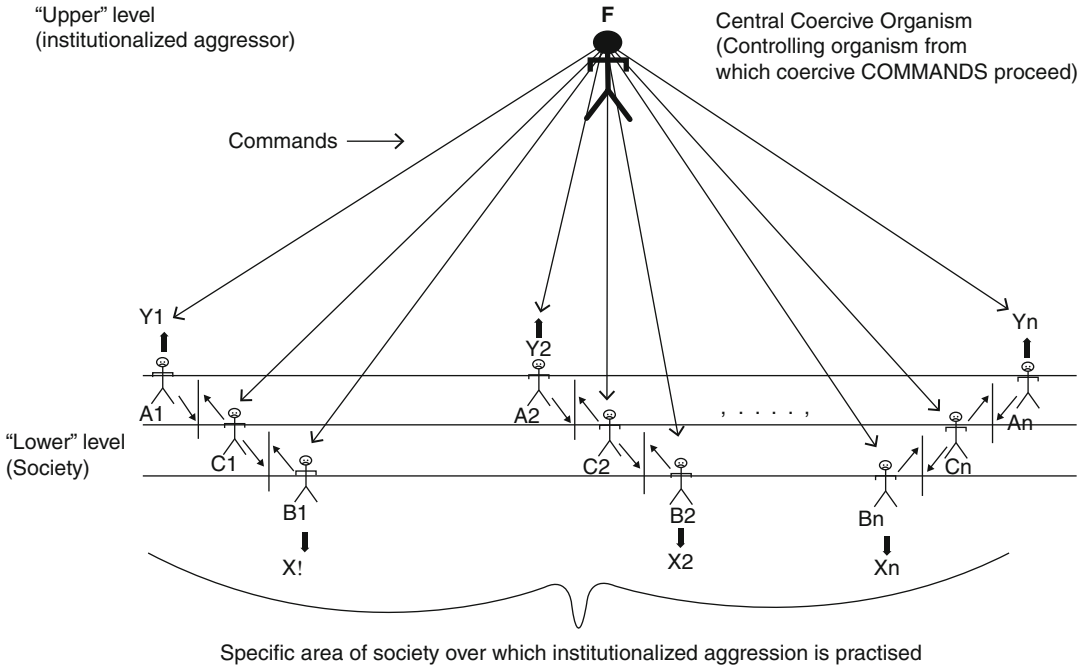
the different human beings will not learn to discipline their behavior in accordance with that of their peers.

Thus, as C cannot carry out entrepreneurship, the system is maintained continuously uncoordinated (Fig. 1): A cannot pursue end Y due to lack of a resource which B has in abundance and does not know what to do with. He, therefore, squanders and misuses it, unaware that A exists and needs it urgently. As a conclusion, the main effect of the planned economy, as it is defined in this text, is to prevent the action of the coordinating forces which make life in society possible. Does this mean that the proposers of the planned economy are advocating a chaotic or uncoordinated society? On the contrary, apart from a few exceptions, the proposers of the socialist ideal defend it because, tacitly or explicitly, they believe or suppose that the system of social coordination not only will be undisturbed by the existence of the institutionalized and systematic violence which they favor, but will be made much more effective by the fact that the systematic coercion is performed by a controlling organism which is supposed to possess knowledge (regarding both the ends and the means) and valuations which are better, both quantitatively and qualitatively, than those which the coerced actors may possess at a lower level. From this perspective, the definition of the planned economy given at the beginning of this section is now completed, stating that *it is all systematic and institutionalized aggression which restricts the free performance of entrepreneurship in a determined social area and which is carried out by a controlling organism which is in charge of the tasks of social coordination necessary in the said area*. Under the following heading, the analysis will discuss the point to which socialism, as defined above, is or is not an intellectual error.

Socialism as an Intellectual Error

Life in society is possible thanks to the fact that individuals, spontaneously and without realizing it, learn to modify their behavior, adapting it to the needs of other people. This unconscious learning process is the natural result of the practice of entrepreneurship by human beings (Kirzner 1973, 1979, 1985, 1989). This means that, upon interaction with his peers, each person spontaneously initiates a process of adjustment or coordination in which new information – tacit, practical, and dispersed – is continually being created, discovered, and transmitted from one mind to others. The problem posed by the planned economy is whether it is possible, by the coercive mechanism, to verify the processes of adjustment and coordination of the conduct of different human beings, which depend upon each other and which are indispensable if life in society is to function – all the foregoing taking place within a framework of constant discovery and new creation of practical information which makes it possible for civilization to advance and develop. The ideal put forward by socialism is, therefore, highly daring and ambitious (Mises 1981, p. 40) as it implies the belief that not only may the mechanism of coordination and social adjustment be made effective by the controlling organism which performs the institutionalized coercion in the social area in question but that, in addition, this adjustment may even be improved by the coercive procedure.

Figure 2 is a schematic representation of the planned economy as it is defined in this text. On the "lower level" are human beings, endowed with knowledge or practical information, who, for this reason, try to interact freely among themselves, although such interaction is not possible in some areas due to institutionalized coercion. This coercion is represented by the vertical lines which separate the figures forming each group. On the "upper level," there is the controlling organism which, as an institution, practices coercion in determined areas of life in society. The vertical arrows in opposite directions, which come from the figures on the left and right of each group, represent the existence of unadjusted personal plans which are typical of a situation where there is a lack of social coordination. Cases of lack of coordination cannot be discovered and eliminated by entrepreneurship because of the barriers imposed by the effect of institutionalized coercion



Planned Economy and Entrepreneurial Function, Fig. 2 Schematic representation of the planned economy (Source: Author)

on entrepreneurship. The arrows which go from the head of the controlling figure toward each human being on the lower level represent the coercive commands which comprise the aggression typical of the planned economy, aimed at compelling the citizens to act in a coordinated way and to pursue end F which is considered "right" by the controlling organism.

The command may be defined as any specific instruction or stipulation, the contents of which are clearly defined, which, regardless of the legal form it takes, prohibits, or compels determined actions to be taken under specific circumstances. The command is characterized by the fact that it does not allow the human being to freely carry out his or her entrepreneurship in the social area it refers to.

Commands are, moreover, deliberate decisions of the controlling organism practicing institutionalized aggression and are aimed to force all the actors to fulfill or pursue, not their personal ends, but the ends of those who govern or control.

In view of the foregoing, planned practices or "socialism" is an intellectual error because it is not theoretically possible that the organism in charge of practicing institutionalized aggression possesses sufficient information to endow its commands with the contents of a coordinating nature. The next section will examine this simple argument with more detail from the overall perspective of the human beings who constitute society and who are coerced.

The Impossibility of Socialism from the Perspective of Society

The Static Argument

First, from the point of view of human beings who interact among themselves and constitute society (the so-called lower level as in Fig. 2), it must be remembered that each of them possesses exclusive practical and dispersed information, the majority of which is tacit and, therefore, cannot be articulated. This means that it is logically impossible to conceive of its possible transmission to the controlling organism (the so-called upper level in Fig. 2). In fact, it is not only that the total volume

of practical information sensed and handled by all human beings at an individual level is so enormous that its conscious acquisition by the controlling organism is inconceivable, but, above all, that this volume of information is disseminated among the minds of all men in the form of tacit information which cannot be articulated and, therefore, cannot be formally expressed or explicitly transmitted to any controlling center.

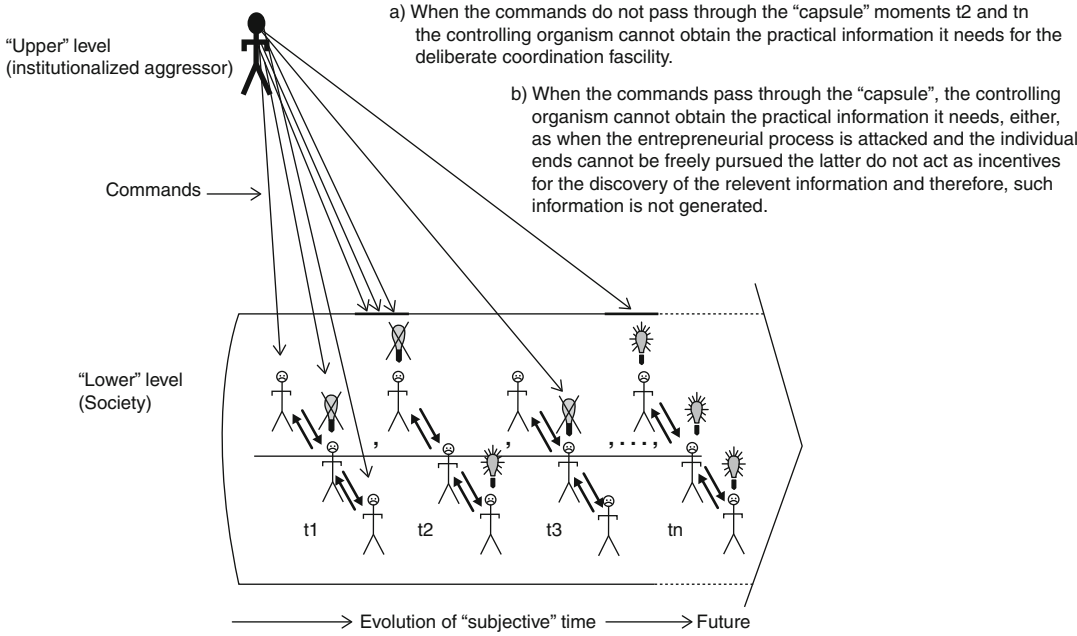
Information relevant to life in society is created and transmitted implicitly in a disseminated way, that is, neither consciously nor deliberately. In this way, the different social agents learn to discipline their behavior in relation to that of other people but are not aware that they are the protagonists of this learning process or that, therefore, they are adapting their behavior to that of other human beings: they are simply conscious that they are acting, that is, trying to obtain their personal ends using the means they believe to be within their reach. Therefore, the knowledge discussed here is a knowledge which is only possessed by human beings acting in a society which, in view of its intrinsic nature, cannot be explicitly transmitted to any central controlling organism. As this knowledge is indispensable if different individual behaviors are to be coordinated socially, thus making society possible, and cannot be transmitted to the controlling organism given the fact that it cannot be articulated, it is logically absurd to think that a planned economic system can work.

The Dynamic Argument

Socialism is impossible not only because the information possessed by the actors is intrinsically unable to be transmitted explicitly, but because, moreover, from a dynamic point of view, human beings, on carrying out entrepreneurship, that is, on acting, constantly create and discover new information. It would be very difficult to transmit to the controlling organism information or knowledge which has not yet been created, but which is continually arising as a result of the social process itself to the extent that the latter is not attacked.

Figure 3 represents the actors who are continually creating and discovering new information throughout the social process. As time, in its subjective sense, elapses, those who perform their entrepreneurship in interaction with their peers are constantly becoming aware of new profit opportunities, of which they try to take advantage. Consequently, the information possessed by each of them is constantly undergoing modification. This is represented in the figure by the different bulbs which light up as time passes. It is clear not only that it will be impossible for the controlling organism to have all the information necessary to coordinate society by commands at its disposal, given that this information is dispersed, exclusive, and impossible to articulate, but also that, moreover, this information will be continually modified and will arise ex nihilo as time passes. It is highly unlikely that it is possible to transmit to the controlling organism information which is at each moment indispensable for the coordination of society but which has not yet even been created by the entrepreneurial process itself.

Thus, for example, when it looks rainy at dawn or there is any other series of meteorological circumstances, the farmer realizes that, as a result of the change in the situation, he/she will have to modify his or her decision on the different tasks that should be done on the farm on that day, without being able to articulate formally the reasons why he/she is taking such a decision. It is not possible, therefore, to transfer this information, which is the result of many years of experience and work on the farm, to a hypothetical controlling organism (e.g., a Ministry of Agriculture in the capital) and await instructions. The same may be said of any other person who carries out his or her entrepreneurship in a determined environment, be it a decision as to whether he/she should invest or otherwise in a certain company or sector, or whether he/she should buy or sell certain stocks or shares, or contract certain persons to collaborate in his or her work, etc. One may, therefore, consider that the practical information not only is, as it were, in a capsule, in the sense that it is not accessible to the controlling organism which practices institutionalized aggression, but, in addition to being in a capsule, is continually



Planned Economy and Entrepreneurial Function, Fig. 3 Dynamic argument against socialism (source: Author)

being modified and regenerated in a new form, as the future is created and made step-by-step by the actors-entrepreneurs.

Lastly, to the same extent as the state coercion is practiced on a more continual and effective basis, the free pursuit of individual ends will be made increasingly impossible and, therefore, the latter will not act as an incentive and it will not be possible to discover or generate the practical information necessary to coordinate society through entrepreneurship. The controlling organism is, therefore, faced with a dilemma impossible to eradicate, as it has an absolute need of the information generated in the social process, which it cannot obtain under any circumstance, because if it intervenes coercively in such process it will destroy the capacity to create information and if it does not intervene, it will not obtain the information either.

As a conclusion, from the perspective of the social process, socialism may be considered as an intellectual error, as, for the following reasons, it is not possible to conceive that the controlling organism in charge of intervening with commands can obtain the information necessary to coordinate society: first, because of the volume (it is impossible for the intervening organism to consciously assimilate the enormous volume of practical information which is spread over the minds of human beings); second, given the fact that the necessary information is essentially impossible to transfer to the central organism (as it is tacit and impossible to articulate); third, because, in addition, it is not possible to transfer information which has not yet been discovered or created by the actors and which only arises as a result of the free process of the practice of entrepreneurship; and fourth, because the practice of coercion prevents the entrepreneurial process from discovering and creating the information necessary to coordinate society.

The Impossibility of Socialism from the Perspective of the Controlling Organism

Second, now from the perspective of what has been called the "upper" level in the figures,

that is, from the standpoint of the person or group of persons, organized to a greater or lesser extent, who, systematically and institutionally, carry out aggression against the free practice of entrepreneurship, a series of considerations can be made which confirm, even more, if that is possible, the conclusion that socialism is simply an intellectual error.

For dialectic purposes, one may accept, as did Mises, that the controlling organism (regardless of whether it is a dictator or leader, an elite, a group of scientists or intellectuals, a ministerial department, a group of representatives elected democratically by "the people" or, in short, any combination, of a greater or lesser complexity, of all or some of these elements) is endowed with the maximum technical and intellectual capacity, experience and wisdom, together with the best intentions, which is humanly conceivable (These hypotheses are not true in reality for the reasons presented below). However, what cannot be accepted is that the controlling organism is endowed with superhuman capacities or, specifically, that it has the gift of omniscience (Mises 1996, p. 92), that is, that it is capable of assimilating, knowing, and interpreting simultaneously all the scattered and exclusive information which is dispersed over the minds of all the beings who act in society and which is continually being generated and created ex novo by these beings. The reality is that the greater part of the controlling organism, sometimes also called the planning organism or organism of central or partial intervention, does not know or only has a very vague idea as to the knowledge which is available dispersed among the minds of all the actors who may be submitted to its orders. There is, therefore, a small or nonexistent possibility that the planner may come to know, or discover where to look for and find, the elements of dispersed information which are being generated in the social process and of which it has such a great need in order to control and coordinate such process.

Moreover, the controlling organism will unavoidably have to be composed of human beings, with all their virtues and defects, who, like any other actor, will have their own personal ends which will act as incentives and lead them to discover the information relevant to their personal interests. Most probably, therefore, the men who constitute the controlling organism, if they use their entrepreneurial intuition correctly from the point of view of their own ends or interests, will generate the information and experience necessary to keep themselves in power indefinitely and justify and rationalize their acts to themselves and to third parties, practice coercion in an increasingly sophisticated and effective way, present their aggression to the citizens as something inevitable and attractive, etc. Contradicting the "well-intentioned" hypothesis set out at the beginning of the preceding paragraph, these will generally be the most common incentives and will prevail over others, particularly over interest in discovering the practical, specific, and relevant information which exists at each moment dispersed over society and which is necessary to make the coordinated functioning of the latter possible through commands. This lack of motivation will determine, moreover, that the controlling organism does not even realize, that is, become conscious, of the degree of its own ineradicable ignorance, sinking into a process which distances it more and more from the social realities which it is trying to control.

In addition, the controlling organism will become incapable of making any kind of economic calculation, inasmuch as, regardless of its ends (and one may again imagine that they are the most "humane" and "morally elevated" ones), it cannot know whether the costs incurred in pursuing such ends have, for itself, a value even greater than the value which it attributes subjectively to the ends pursued. The cost is merely the subjective value which the actor attributes to what he/she must renounce in pursuit of a determined end. It is obvious that the controlling organism cannot obtain the knowledge or information necessary to become aware of the true cost incurred in accordance with its own scale of values, as the information necessary to estimate costs is spread over the minds of all the human beings or actors who make up the social process and who are coerced

by the controlling organism (democratically elected or otherwise) in charge of systematically practicing aggression against the body of society.

Conclusion and Future Directions

If the concept of responsibility is defined as the quality of the action which is executed once the actor has come to know the cost thereof and takes such cost into account by the corresponding estimated economic calculation, it may be concluded that the controlling organism, regardless of its composition, system of choice, and value judgments, as it is unable to see and appreciate the costs incurred, will always tend to act irresponsibly. There exists, therefore, the unresolvable paradox that the more the controlling organism tries to plan or control a determined area of life in society, the fewer possibilities it will have of reaching its objectives, as it cannot obtain the information necessary to organize society, creating, moreover, new, serious imbalances and distortions to the precise degree that its coercion is carried out more effectively and limits the entrepreneurship of human beings. One must, therefore, draw the conclusion that it is a serious error to think that the controlling organism can make economic calculations in the same way as the individual entrepreneur. On the contrary, the more developed the planned organization, the more practical first-hand information which is indispensable for economic calculation will be lost, making economic calculation completely impossible to the precise degree to which obstacles to free human action are placed by the organism practicing institutionalized coercion.

Cross-References

- ▶ Entrepreneurial Creativity
- ▶ Entrepreneurship
- ▶ Institutional Coercion
- ▶ Knowledge

References

Hayek FA. The constitution of liberty. London: Routledge; 1959.
Hoppe HH. A theory of socialism and capitalism. Amsterdam: Kluwer; 1989.
Huerta de Soto J. Socialism, economic calculation and entrepreneurship. Cheltenham/Northampton: Edward Elgar; 2010.
Kirzner IM. Competition and entrepreneurship. Chicago: University of Chicago Press; 1973.
Kirzner IM. Perception, opportunity, and profit. Chicago: University of Chicago Press; 1979.
Kirzner IM. Discovery and the capitalist process. Chicago: University of Chicago Press; 1985.
Kirzner IM. Discovery, capitalism, and distributive justice. Oxford: Basil Blackwell; 1989.
Rothbard MN. Power and market: government and the economy. Menlo Park: Institute for Humane Studies; 1970.
von Mises L. In: Greaves BB, editor. Human action: a treatise on economics. 4th ed. New York: Foundation for Economic Education; 1996.
von Mises L. Socialism: an economic and sociological analysis (trans. Kahane J). 3rd ed. Indianapolis: Liberty Press; 1981.

Planning

- ▶ Small Businesses - Value, Transmission, and Recovery
- ▶ Strategic Scanning of SME

Planning Lessons

- ▶ Teaching as Invention

Policy – Line, Program

- ▶ Institutional Entrepreneurship, Innovation Systems, and Innovation Policy

Political Change

- ▶ Innovation and Democracy

Political Creativity

► Political Leadership and Innovation

Political Entrepreneurship

► Political Leadership and Innovation

Political Leadership and Innovation

David M. Wineroither
Department of Political Science, University of Innsbruck, Innsbruck, Austria

Synonyms

Human inequality; Political creativity; Political entrepreneurship

Political leadership, in a parsimonious definition, refers to the impact on decision-making and political outcomes that results from action by the holder of political office. Thus, it is connected with leadership style and may be rooted in certain character traits of the leader's personality.

As such, however, it is at odds with core principles of democracy, most evidently equality coupled with the doctrine of popular sovereignty and guarded by the constitutional division of powers. Democracy ultimately rests on the premise of the rule of many embedded in rule of law. Hence, in terms of liberal and democratic theory, political leadership and democracy are contradictory.

Speaking empirically, the relationship between the two is slightly more ambiguous. The practice of liberal democracy is based on – the ensurance and endurance of – representatives' accountability and responsivity. Voters are principals, who direct as their agents politicians. Consequently, the relationship between innovation and political leadership is asymmetric, predominantly established by innovations *in* economy, society, and media and their effect *on* political leadership.

The Modus Operandi of Political Leadership and Democracy

Where to Find Potential Leaders: Bringing States Back In

Although liberal democracies by definition and in practice seek to level out hierarchies and disperse power, political leadership in the world of democratic politics is not entirely absent. After all, change describes the essential trigger of leadership. For the sake of simplicity, this entry will not differentiate (a) between various decision-making arenas and (b) over the course of decision preparation, decision-making, and policy implementation/supervision.

In the reality of political change taking place in liberal democracies, the term innovation denotes medium-scale impact. It hereby markedly differs from the large-scale leadership possible under dictatorship on one hand, and the mere office holding typical for some democracies characterized by extensive power sharing on the other hand. Blondel, in his two-dimensional typology of potential leadership impact (Blondel 1987: 97), defines "innovators" as those bringing about large change limited by specialized scope (thereby exceeding the routinized maintenance-oriented role of the managerial type). At this scope, typically policy areas are addressed and "innovators" as implementers of new policies get identified, e.g., land reform.

However, it is difficult to find clear examples of political leaders in democracy fulfilling these criteria. Adaptive reaction and response to changes and challenges characterize the relationship between change and political leadership, whereas leaders rarely implement large-scale changes, alter procedural rules of the game, or redirect public response in problem-solving tasks. An entrepreneurial style initiative of politicians culminates mostly in adaptive response,

and even pioneering leadership seldom unfolds any revolutionary appeal.

Having said this, macro-level political and economic developments in the course of the twentieth century raised doubts as to whether politics does matter at all. Globalization hand-in-hand with the emergence of civil society has imposed challenges to prerogatives of national politics to govern authoritatively and effectively. Nation states and hence national governments have witnessed considerable pressures from:

- Outside (economic globalization and transnational companies)
- Above (supranational political and economic bodies)
- Below (NGO's, public dissatisfaction with representatives/parties)

This has lead to "hollowing out" in the sense of reduced steering capacity. Against this background, critics have described conventional political competition as virtual and political decision as either overthrown or dominated by (organized) business interests (coined "post democracy"). Why then not focus on political leaders in civil society? In the end, negotiations of state actors and policy networks (the paradigm of governance) still take place in the shadow of hierarchy. In turn, if individual politicians matter at all, leadership potential would be obviously limited to those few ranked on the top. The "empty box" character of executive politics, however, has put severe limitations on attempts to probe into empirics of executive leadership. Tellingly, social scientific study of leadership in its beginnings was characterized by the absence of state-centeredness but instead was preoccupied with the wealth of phenomena related to leadership in "voluntary organizations," most notably churches and trade unions.

Somewhat seconding and affirming this notion, cross-country analysis shows substantial variation in the formal powers of presidents and prime ministers. The (d)evolution of powers offers much insight: when chief executives indeed played a key role in institutional redesign, it had almost never been an attempt to expand their power base. Quite the opposite, it mostly had the intended effect of shifting power away, as was the case with devolution under Tony Blair in Great Britain and reforms in a number of semi-presidential countries.

The Interplay of Office, Personality, Leadership Style, and the Role of Creativity

Constitutional democracy consists, among others, of rule of law and has established separation of powers. Beyond that, however, it stipulates the approximation of popular will by government realized through fair and, in this sense, competitive elections (resulting in many countries in "responsible party government"). The notions of moral hazard and rent-seeking, figuring prominently in applications of rational choice theory, signal the threat of undermining responsivity and accountability in principal agent relations. Inevitably, therefore, neither a certain formal position nor character trait, or leadership style on its own, guarantees political leadership, whether pioneering, innovative, or merely adaptive in nature. This holds true even for the combination of great political powers in the hands of a charismatic holder of office. Looking at "idolized heroes" (e.g., John F. Kennedy), Burns denied they could act as transformative leaders because "no true relationships exists between them and the spectators – no relationship characterized by deeply held motives, shared goals, rational conflict, and lasting influence in the form of change" (Burns 1978: 248).

To provide an interim summary, political leadership in democracy is highly contingent and requires a careful analysis of institutional and cultural parameters as well as situational factors. For instance, in some countries, institutional pluralism has led to the notion of "semi-sovereignty," most notably Germany, where effective leadership rather depends on means of coordination than authoritative decision-making. In many countries, extraordinary leaders (often those privileged as first holders of the office following its creation and those acting in times of crisis) established themselves as widely accepted role models (Washington, FDR, Germany's Adenauer). In the USA, ambiguities of the constitution allowed single presidents in the early age of the presidency acting as innovators. Typically,

across Western democracies, innovative leaders would be succeeded by inheritors, and strong leaders would be followed by mediocre ones.

Focusing on leaders' personality, even if top-level politicians were willing to take on entrepreneurial routes of leadership, basically risk taking and initiative, they usually lack the creativity required to make a difference. Here one deals with collective inability stemming from politics as career (resembling "politics of survival"), in contrast to politics as vocation. In addition, political leaders today lack the time to familiarize with political theory and develop original political thoughts. Eventually, this appears also to be a product of biographical standardization that inspired observers to conceptualize politicians (elected and/or appointed) as members of a political class, constituted by similar social and educational background as well as shared political interest. As Tucker writes on political creativity, "[A]t bottom it is a gift bestowed on some individuals by nature and life circumstances in combination" (Tucker 1977: 386).

This image of political class provides stark contrast to the agency of political competition in democracy for allowing innovation in the spheres of science, business, and media. As Carayannis and Campbell emphasize for the genuine feature of political competition in democracy, "Political pluralism in democracy cross-refers to creativity-encouraging heterogeneity and diversity of different forms, modes and paradigms of knowledge and innovation" (Carayannis and Campbell 2011: 342).

One step further, in distinguishing seven different forms of bad leadership, Kellerman links lack of creativity with innovative malfunctioning: "Although they may be competent, they are unable or unwilling to adapt to new ideas, new information, or changing times" (Kellerman 2004: 419). The alternative selection modus based on policy expertise (mostly occupational, often managerial, sometimes genuinely scientific) has not proved to overcome such shortcoming. Experts given political mandates plausibly scored even lower compared to professional politicians in terms of political creativity. Similarly, policy expertise and involvement of leaders as professional politicians "may make powerful prime ministers in parliamentary democracies but at the same time it stands out as a central feature of some only moderately successful US presidents" (Helms 2012).

Overall, boundaries between leader and follower roles have been blurred in Western democratic societies. Especially for a public that is both more politically involved and dissatisfied, authoritative top-down decision-making has become costly for its exponents. There is some evidence that effective leaders in current democratic societies act as agents of followers and that performance of allegiance roles to publics lies at the heart of executive leadership. To some observers, leaders are not only bound to popular will but as leaders they appear to be "created by the led" (Kellerman 2004). Consequently, in this perspective, follower action in many instances determines the success and failure of leaders. At the very bottom of the relationship between leaders and followers, as in foreign politics, one of the prime leadership tasks is to generate "soft power" and to combine its means creatively with "hard power."

Political Competition and Innovative Forms of Leadership

Schumpeter's Entrepreneurial Style Leaders

Various theorists of democracy have employed market metaphors in describing the logic of the political process. Among them, Joseph A. Schumpeter stands out for assuming an imperfect market in politics (Schumpeter 1950). Already in his theory of development he had firmly emphasized the incompatibility of perfect competition and economic progress. According to him, "Practically every innovation (. . .) at first creates that kind of situation which is designated by the term Monopolistic Competition" (Schumpeter 1989: 167). The political process in representative democracy exhibits oligopolistic as well as monopolistic features because it is geared toward majority building and interest aggregation, which is ultimately required to secure governability. Furthermore, as elections take place rather

infrequently in a world of information (dis-) advantage and passive roles of some constituents, this results in rather low competence levels compared to the sphere of economics.

The Schumpeterian assumption of imperfect markets contrasts, e.g., the economic theory of democracy elaborated by Anthony Downs, which rests on the neoclassical equilibrium model of economy. It is exactly this difference that allows for leadership to be regarded as a potential driver of the political process and the sole originator of endogenous qualitative change. Equating the influence of entrepreneurship in business, leadership in politics in Schumpeter's view has the effect of creating new demand on the side of customers, who are of course the voters in the political realm. Unlike in the equilibrium model of Downs, leaders are not forced to perpetually trail behind shifting voter preferences but quite the contrary are able to shape those. For Schumpeter, again in contrast to Downs, the political process is multidimensional and voters' preferences are multi-peaked, producing cyclical majorities.

Thus, innovative entrepreneurial style leadership for Schumpeter displays a permanent association to politics and can be exercised by leaders as political entrepreneurs again and again. But what can be understood as "political innovation" in the Schumpeterian sense? In any case, innovation is the crucial element in creating qualitative change, consisting of something untried and irreversible, and perhaps even difficult to be repeated, at least by mere imitation. Though Körösényi lists a number of ways to affect public policy, he ultimately regards all of them as being rooted in the ability to "overcome resistance" (2011: 10). Similarly, as noted above, the overall character of political competition is oligopolistic because of the need to create political majorities.

Riker's Heresthetics

Schumpeterian accounts of entrepreneurial leadership share a commonality in their rootedness in political competition. If political leaders are perceived as innovators themselves, they would act as agents of ideas and policies with the ultimate goal to create political majorities at different levels and places in the political process (e.g., the public, in cabinet, in nonmajoritarian institutions, at the decision-making stage, in the phase of implementation, throughout a process of supervision and reevaluation). Following Schumpeter, William H. Riker has shown in his seminal work on *heresthetics* how political actors motivated to win politically may successfully combine agenda setting abilities with rhetorical skills and manipulation of issue dimensions to create new majority coalitions (Riker 1986).

Innovative leadership for Riker means manipulation in order to win. Based on positive political theory, he identified three crucial ways that may make a politician succeed, in addition to the evergreen influence of rhetorics in persuading others. The heresthetic leader skillfully employs three categories or strategies: agenda control, strategic voting, and manipulation of dimensions. As social choice theory has emphasized, voting outcomes are closely related to voting procedures (e.g., Condorcet paradoxon: A wins over B, B wins over C, C wins over A). Moreover, those called upon to vote show a plurality of preferences characterized by different salience and distance to ideal points. From this perception, it follows that redefinition of the situation and/or moderate strategic shifts of the political measures envisaged create plenty of opportunity to rally alternative, stronger coalitions of support.

According to Riker and empirical investigations of a number of scholars, political change as an outcome of *heresthetics* is a rare event when looking at really important issues (motions). The leadership-based "invention of a new viewpoint" alone, not to speak of environmental resistance and the (counter-)strategic moves of many other actors involved, requires literally "artistic creativity" as Riker resumed himself (Riker 1986: 1, 34).

The Impact of Knowledge Revolution on Political Leadership

Knowledge Society and Programmatic Competition

The concept of "knowledge society" was developed at the eve of postindustrial society. Knowledge society, embedded in welfare states of

varying size, has led to massive job creation in the educational and health sector. This development has facilitated the emergence of two-dimensional political space. Parties and candidates, once solely competing in the redistributive left–right dimension, now also are judged on sociopolitical and sociocultural grounds. The opening-up of political space limits the ability of both parties and leaders to rally heterogeneous voting coalitions behind them (Kitschelt and Rehm 2011); this, in the sphere of party choice, goes at the expense primarily of centrist catch all parties, while it opens up leverage for entrepreneurial style populist leaders that combine charisma with broking skills (to overcome programmatic inconsistency) as long as they do not enter government, e.g., Bossi in Italy, Haider in Austria, and Wilders in the Netherlands. Often, innovation in political leadership in this respect takes the form of reshaping and redrawing group boundaries. The above-mentioned prime exponents of entrepreneurial style leaders in politics profit from the rise of cultural and identity politics relative to redistributive politics, a process resulting in political realignment of the working class.

Knowledge Democracy and Entrepreneurial Leadership

At times political leaders become subject to innovation attached to central goals of the political process. This is most prominently the case for the trend of personalization transmitted by the multimedia age. The innovation of candidate debates on screen revealed substantially different performances across countries and in some cases probably decided the race for office, e.g., in the 1960 campaign for American presidency.

Technical innovation has affected governing in the media age quite profoundly. Yet, it has not made political leadership more likely, far-reaching, rooted in personality, or innovative. Leaders have increasingly become the center of public attention, and electoral campaigns (making them more vulnerable to public failures and dependent on high approval rates) are "sold" as brands and often engage in unmediated communication with public (the hypothesis of presidentialization of prime ministers).

The emerging concept of knowledge democracy by definition assumes from the presence of network society and media politics great demand for a new mode of governance as legitimacy of traditional representative democracy unpreventably vanishes. It therefore puts a premium on institutional and functional reform. Consequently, advocates of the concept of knowledge democracy have largely bypassed aspects of leadership by individuals (e.g., In 't Veld 2010). Governance appears to be a substitute for government. It should be noted, however, that at a closer look governance and government do not constitute polar extremes but are able to coexist and supplement each other (Helms 2012). While proponents knowledge democracy tend to largely ignore the intact linkages between citizens and parties/politicians (and the above mentioned realignment in favor of populist radical right parties), it also has identified a connectedness of media revolution and populist leadership. More specifically, this kind of leadership proved successful when exerted by political entrepreneurs.

Linkages between political entrepreneurship and leadership might be created in two ways. First, business leaders may enter (sub-)national politics; second, politicians may exercise leadership tasks by conscious or unconscious orientation toward entrepreneurial activities. Most importantly, and by far most prominently, political leaders as entrepreneurs "sell" themselves (*branding*). In some notorious cases, they do so supported by the mass media that they themselves own. In Italy, media tsar Berlusconi aspired a formal leadership position and was elected prime minister a number of times. His success rested on widespread distance to more conventional political parties in many Western democracies and his image as self-made billionaire.

Again, the case of Berlusconi demonstrates the contextuality and crisis boundness of political leadership – Berlusconi initially profited from the breakdown of the established party system in Italy in the early 1990s. The kind of innovation that emanated from his entrepreneurial style leadership, however, hardly could be described as generating a surplus to quality of democracy

(equating Schumpeter's "creative destruction"). New public demand was created due to appeals of politainment, met by the prime minister in the guise of anti-politics. In other words, he was offering a combination of somewhat effective leadership and bad governance. Accordingly, the founded political vehicles, avoiding traditional party image, are presented in the fashion of political movements. Whether this self-description accurately depicts the actual operative mode is much debated in current comparative party political research.

Conclusion and Future Directions

Constitutional democracy in interaction with knowledge society leaves virtually no ground for old style political leadership. This applies, for instance, to leadership as a reflection of a politician's personality and forms of top-down individual leadership. When political leadership is tangible, structural features and contextual factors clearly outnumber effects of personality and leadership style.

While innovative political leadership in general is hard to be established, entrepreneurial style leadership in politics has flourished as a consequence of transformation and innovation in

- Economy (e.g., postindustrial job creation)
- Society (e.g., individualism, pluralization of lifestyles, political aspiration of NGOs)
- Media (e.g., Internet access, televized candidate debates)

This populist entrepreneurial version of political leadership, at best, possesses a mixed record in terms of quality of democracy. At the same time, societal demand for innovative leadership prevails and should be accommodated. Political leadership has to be rescued as an effective mode of governance through conceptual and practical innovation. Most importantly, potentially effective leaders would have to accept the logic of network society and dispersed democratic leadership. Furthermore, they have to gain awareness that reshaping of group identity as this is one vital and perhaps dominating cleavage in the future, and they are needed to develop an inclusionary vision of, e.g., citizenship.

It seems justified to discover to lie at the heart of both innovative political leadership and innovation *in* political leadership securing trust in politicians. For that purpose, leaders (a) collectively are demanded to pursue institutional reform of the selection process of politicians at all levels, envisaging greater biographical variation (the import of self-made billionaires, economic entrepreneurs, and policy experts does not sufficiently compensate for that). (b) With reference to political communication, the collective of leaders is required to practice a mix of blame avoidance, credit claiming and technocratic policies both in order to foster political legitimacy, realize good governance conduct, and satisfy output criteria. Likewise, looking upward, it makes rescaling of people's expectations in political leaders necessary.

These are prerequisites in search for acceptance of a mixture of representative and direct democracy in a shrinking world of "hollowing out" of core executive politics. Still in the future, political leaders will play a pivotal role in finding balance of, in the words of Abraham Lincoln, government of, for, and by the people – a matter far too big to be dealt with by political leaders as individuals.

Cross-References

- ▶ Creative Leadership
- ▶ Entrepreneurial Capability and Leadership
- ▶ Innovation and Democracy
- ▶ Innovations of Direct Democracy
- ▶ Joseph A. Schumpeter and Innovation
- ▶ Knowledge Society, Knowledge-Based Economy, and Innovation
- ▶ Quality of Democracy and Innovation
- ▶ Schumpeterian Entrepreneur

References

Blondel J. Political leadership: towards a general analysis. London: Sage; 1987.

Burns JM. Leadership. New York: Harper & Row; 1978.

Carayannis EG, Campbell DFJ. Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation concepts and the "Mode 3" knowledge production system. J Knowl Econ. 2011;2(3):327–72.
Helms L. Poor leadership and bad governance: conceptual perspectives and questions for comparative inquiry. In: Helms L, editor. Poor leadership and bad governance: revisiting presidents and prime ministers in North America, Europe and Japan. Cheltenham: Edward Elgar; 2012; 1–15.
In 't Veld RJ, editor. Knowledge democracy: consequences for science, politics, and media. Berlin/New York: Springer; 2010.
Kellerman B. Bad leadership: what it is, how it happens, why it matters. Boston: Harvard Business School Press; 2004.
Kitschelt H, Rehm P. Party alignments. Change and continuity. Paper delivered at the conference on the future of democratic capitalism. University of Zurich, 16–18 June 2011, Zurich.
Körösényi A. Innovative leadership and the politics of disequilibrium. A Schumpeterian account of the role of leadership. Working papers in political science 2011/5, Institute for Political Science, Hungarian Academy of Sciences. http://www.mtapti.hu/pdf/wp_korosenyi.pdf (2011). Accessed 25 June 2012.
Riker HW. The art of political manipulation. New Haven/London: Yale University Press; 1986.
Schumpeter JA. Capitalism, socialism and democracy. 3rd ed. New York/London: Harper; 1950.
Schumpeter JA. In: Clemence RV, editor. Essays: on entrepreneurs, innovations, business cycles, and the evolution of capitalism. New Brunswick/London: Transaction Publishers; 1989.
Tucker RC. Personality and political leadership. Polit Sci Q. 1977;92(3):383–93.

Polynomiography and Innovation

Bahman Kalantari
Department of Computer Science, Rutgers,
The State University of New Jersey,
New Brunswick, New Jersey, NJ, USA

Synonyms

Art-Math; Fractal; Visualization

Introduction to Polynomiography and Its Applications

Throughout the history of science, reaching back to the Sumerians in the third millennium B.C., the task of finding the *zeros* of *pol*ynomials has been one of the most influential in the development of mathematics. The problem has been studied by the most famous of mathematicians and even today, it remains to be a useful problem in every branch of math and science.

Finding a zero of a polynomial is solving for the unknown. Solving for the unknown is a necessity in life and human survival. The task has played a significant role in the development of human intellect, leading to advancements in math, science, and art. A layman may need to figure out what is 17 % of 85. This amounts to solving a linear equation. A carpenter may need to estimate the length of the diagonal of a square having sides of a particular size. This is already the beginning of something deep: computing square-roots, a very special case of solving a quadratic equation taught in middle and high schools across the entire world. These are examples of polynomial equations.

Even though a very small percentage of the world population may actually know the quadratic formula, solving a quadratic equation is a need in everyday life. Of those who know the quadratic formula, an even a lesser percentage knows how to estimate a mundane number such as the square-root of two. They would need the use of a calculator. How does a calculator compute the approximation of the square-root of a number? How can the twentieth or even one-millionth digit in the decimal expansion of the square-root of two be computed?

The famous American artist Jasper John has an axiom describing how one may create art: "Take an object. Do something to it. Do something else to it." What he is perhaps suggesting is *iteration*. Before him, Isaac Newton suggested a method for finding the square-root of two, or the square-root of any other number: Take an initial guess. Then iterate by a certain recipe that would become known as *Newton's method*

to get a new estimate that would hopefully come closer to the actual value of the square-root, i.e., having more accuracy. Then iterate again with the new estimate and repeat this process.

Formally, a polynomial, written as $p(x)$, is defined as a linear combination of integral powers of a variable, say x. Thus, a polynomial is sum of terms such as 16, $7x$, $-24x \bullet x$, $5\ x \bullet x \bullet x$, etc. Here "•" *means multiply*. When x is multiplied by itself so many times, it is convenient to write this with an exponent having integral powers. Thus, the integral powers in the examples are 0, 1, 2, and 3. The highest integral exponent of x is called the *degree* of the polynomial and the constant multipliers are called *coefficients*. The degree of a linear equation is one and that of a quadratic is two, and so on. A *zero* or a *solution* to a polynomial equation is a value such that when substituted for x and simplified, the equation yields a value of zero. To formally compute 17 % of 85 is equivalent to solving the linear equation, $17\ x - 85 = 0$. To find the square-root of two is equivalent to solving the quadratic equation $x \bullet x - 2 = 0$.

A celebrated theorem about polynomials is the *Fundamental Theorem of Algebra (FTA)*, first proved by one of the greatest mathematicians of all times, Carl Friedrich Gauss. The theorem guarantees that a polynomial has as many zeros as its degree. The solution to a polynomial equation is not always a real number, but the FTA guarantees that a *complex number* will always exist as a zero of the polynomial. A complex number is an object of the form $a + \mathbf{i}b$ where a and b are ordinary numbers corresponding to *real* and *imaginary* parts, respectively, but $\mathbf{i}$ is a symbol that obeys the rule, $\mathbf{i} \bullet \mathbf{i} = -1$. With this convention, the point in the Euclidean plane having coordinate (a, b) becomes a number, a complex number. Then, like the ordinary numbers, two complex numbers can be added, subtracted, multiplied, and divided by each other. This turns the points in the plane into objects that can be algebraically manipulated. Two teenagers can play a game with locations: One could tell the other to meet him at a location x such that when multiplied by the location of the cafe A becomes the location of the theater B. In summary, the roots of a polynomial equation are or correspond to locations in the Euclidean plane.

It is not always possible to find the exact value of zeros of a polynomial. The square-root of two is an example. The exact value of zeros of a quadratic polynomial cannot always be computed, even though an exact formula is available, namely, the high school quadratic formula. Even worse, a deep but negative result about polynomials asserts that for polynomials of degree five or higher, there is no general formula for their zeros. Thus, at best, the roots of a general polynomial can only be approximated. However, this can algorithmically be achieved to any desirable accuracy. Given a polynomial $p(x)$, Newton's method can be viewed as an iterative process that takes a point in the plane and moves it somewhere else, then somewhere else, repeating the process in the hope of getting closer and closer to a root.

Polynomiography can be considered as a visualization of the root-finding process, driven by the FTA. However, the goal of Polynomiography is not the mere approximation of the location of the roots of a polynomial equation, but the entire process of finding the roots and the way this process influences all other points within a particular rectangular region that may or may not include any of the roots. This results in capturing 2D images called the *Polynomiograph*. The process of root-finding is not limited to the use of Newton's method. Polynomiography software offers much more. Like a camera that offers many lenses, settings, and parameters to capture photographs of a single object, Polynomiography software offers many processes (*iteration function*) that are encoded as algorithms for solving polynomial equations, as well as many coloring schemes. These essentially make it possible to capture an infinite number of Polynomiographs from a single equation.

Polynomiography software makes use of the many encoded processes to create artwork. In particular, in the context of visualization and art, one can reverse the role of the ancient root-finding problem and select the location of roots so as to create desirable designs or effects.

Polynomiography and Innovation,
Fig. 1 Example Polynomiographs from single polynomials (Bahman Kalantari)

Polynomiography thus turns the root-finding problem upside down and into a visualization tool of art and design, and a serious medium for creating artwork of great variety and diversity through a combination of human creativity and computer power. The following metaphoric description is from the book (Kalantari 2008):

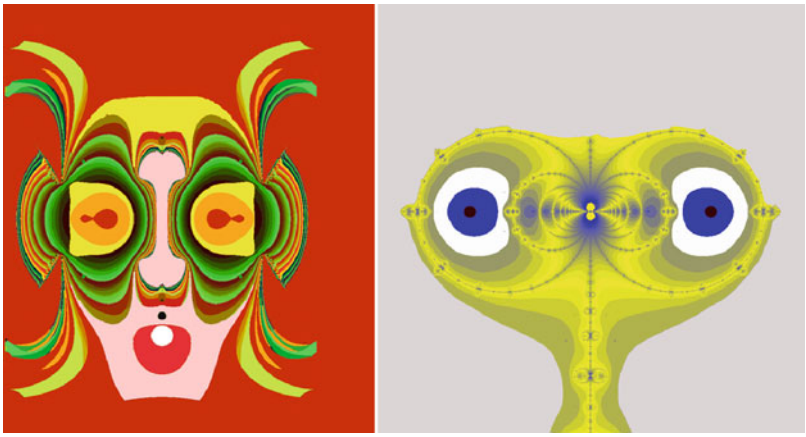
> Solving a polynomial equation could be considered as a game of hide-and-seek with a bunch of tiny dots on a painting canvas. We hide the dots behind a polynomial equation, we then seek them using a formula or an algorithm. Polynomiography is the algorithmic visualization of the process of searching for the dots, and painting the canvas along the way.

On the one hand, Polynomiography can be considered a digital form of painting, using only a finite set of points, the roots of a polynomial as the generating set. As such it is an art form capable of creating a vast variety of images by manipulating this finite set of points, whether given implicitly through the coefficients of a polynomial equation, or selected explicitly as the roots by the clicks of a mouse. In a sense, Polynomiography is a minimalist and abstract art form, albeit one of enormous power and diversity. What is magical in Polynomiography is that this finite set of points, when combined with one or many iteration functions that are made transparent to the Polynomiography software user, results in a coloring scheme, giving a 2D Polynomiograph. Thus, the initial set of points offer much more than the shape it defines. The input set is very small while the output set is a full 2D image. The Polynomiographer's personal creativity and choice, and the great variety of methods to view a polynomial equation amount to a powerful tool for artistic creation. Even with polynomials of small degree, artists, teachers, or students can learn to produce interesting images on a laptop computer in a reasonable amount of time. Some examples are given in Figs. 1–3, using Polynomiography software.

Polynomiography and Innovation,
Fig. 2 Sample artwork, the *bottom* image is from tiling of a single Polynomiograph (Bahman Kalantari)

Innovative Possibilities of Polynomiography in Education

Polynomiography is based on sophisticated algorithmic visualization in solving polynomial equations. Using inventive programming, it creates a medium where an individual, independent of his/her mathematical background, age, and artistic background, is rewarded with satisfying images, while being playful, experimental, artistic, expressive, or scientifically curious. Very significantly in the cases of younger individuals, Polynomiography helps them learn about concepts in mathematics that they would otherwise be much less motivated to study or would find too dry. Polynomiography can be used as the basis of a technology that would lend itself to the encouragement of creativity and innovation in multidisciplinary teaching and learning experiences. It can lead to development of curricula for a wide range of educational courses in K-12 and higher education.



Polynomiography and Innovation,
Fig. 3 Polynomiography could even result in characters, artistic (*left*) and cartoon-like (*right*) (Bahman Kalantari)

Prototype Polynomiography software in several settings has already been tested, and proven to be an enthusiastically popular medium for students in middle and high schools, and teachers who are interested in introducing it in their curricula. Survey of students (some as young as 11–13) who have been introduced to Polynomiography shows that these students have become, as a result, interested in learning about polynomials which are central to mathematics and science. Thus, young students get closer early on to these critical building blocks of sciences and mathematics and related complex notions that are otherwise too distant to them.

On the one hand, polynomials are one of the most important building blocks of mathematics, science, and engineering, having numerous applications. Polynomials help approximate functions which in turn approximate science and modeling. In education, polynomials are indispensable abstract objects as well. Through them, students are introduced to more general functions, graphs, equation-solving, calculus, and much more. On the other hand, mathematics education needs to popularize the subject because mathematics is often considered to be dry and not visual enough. Polynomiography can help young students who are always in the need for visual stimulation to connect to mathematics through playful learning and creativity. This in turn will help them learn complex math. Polynomiography is a medium that helps students play, express themselves, enjoy themselves, while picking up easy mathematics, medium mathematics, and even sophisticated mathematics to reach new frontiers in math and science. This in turn has profound consequence in science and culture.

Polynomiography is a by-product of the author's theoretical research into the ancient but historically significant problem of solving polynomial equations. It has received enthusiastic support from artists, engineers, mathematicians, scientists, and the general public, many of whom await a more robust and complete version of the software. This interest stems from the fact that they all foresee new applications to their particular fields. Polynomiography is also related to *fractals* through the process of iteration and as a result, some of its images are in fact fractal, more precisely, *fractal Polynomiographs*. However, it is not a subset of fractals. The word *fractal*, invented by Mandelbrot, see (Mandelbrot 1983) and (Mandelbrot 1993) is associated with many processes resulting in self-similarity. In addition to fractal Polynomiographs, Polynomiography also result in images that are not fractal in any sense. It is a much more focused subject than fractals based on general iterations. This feature of Polynomiography together with the fact that it has a well-defined foundation, namely, root-finding, makes it a more easily appreciated subject than general fractals. It is this basic foundation and the fact that

polynomials are so widely present in science and math that turns Polynomiography software into a meaningful tool. This can be contrasted with playing with any software that merely renders images based on an iteration which may not enjoy any meaning, or not be designed to do a particular task. Indeed Polynomiography can be used to teach about fractals and turn the concept into a more tangible subject. In the context of fractals, Polynomiography allows *control* and this feature is very significant. In terms of imagery, Polynomiography also enhances and strengthens fractals because it makes use of more sophisticated iterative methods. Aside from the fractal images in Polynomiography, some of its techniques give rise to very rich class of non-fractal images. This can be seen in some examples images given in the Figs. 1–3. For more details on Polynomiography and its foundation, see (Kalantari 2004a, b, 2005, 2008) and the other references.

Innovative Possibilities of Polynomiography in Art

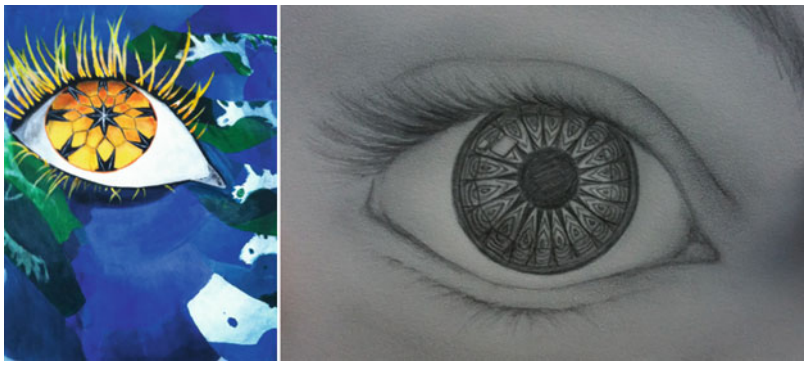
Artistically speaking, Polynomiography can be described as a minimalistic art form capable of creating interesting variety of artwork. The collective shape of the points, their relative gravity with respect to each other, as dictated by the iteration functions which are analogous to the lenses of a camera, and the window through which a polynomial is viewed, together with the Polynomiographer's personal creativity and choice of coloring could all result in a tool of infinite artistic capabilities. Not only can Polynomiography bring art and design into mathematics' and sciences' curricula and education, it can bring mathematics and computer technology to artists who may normally not use mathematics. An artist can learn techniques without the need to have learned the underlying math or algorithms. Thus, Polynomiography offers new creative and innovative possibilities for artists. Polynomials, these fundamental objects of sciences and math, will suddenly find wider and deeper appreciation by the population at large. Just as a camera could help turn a photographer into an artist, Polynomiography software can turn a person not considered an artist to think differently of art and conceive of possibilities that would not have been imagined otherwise. Like photography and painting, many techniques can be developed in Polynomiography and Polynomiographers can discover new techniques of their own, possibly even combining two or more different artforms. Some examples of such work are given in Figs. 5–9. These are produced by the author's students or collaborators.

The author has developed and taught different courses on Polynomiography at Rutgers University to undergraduate students and to high school students at summer, see (Fig. 4) programs. In an interdisciplinary course taken by students from different majors, students must complete a project based on their interest area while using Polynomiography software. The student projects have ranged from such diverse applications of Polynomiography as: art, dance, linguistics, psychology, math, education, computer graphics, computer science, symbology, music, architecture, ecology, neuroscience, special education, chemistry, and religion.

Entrepreneurial and Commercial Possibilities of Polynomiography

Polynomiography is a US patented technology that can lead to a variety of commercial products such as software and other induced products. As a software tool in K-12 education, it has tremendous potentials as evidenced by teachers and students themselves, ranging from 6th to 8th graders to high school students and higher education. It has the potential to be introduced to K-12 education not only in the USA but other countries. In fact, some high school students in USA, Austria, Japan, and South Korea have already gained favorable experiences with the software. This by itself is a promising area of entrepreneurship and could lead to an industry

Polynomiography and Innovation, Fig. 4 A summer Polynomiography workshop for New Jersey high school students at Rutgers (Governor's Summer School of Engineering and Technology, 2011)

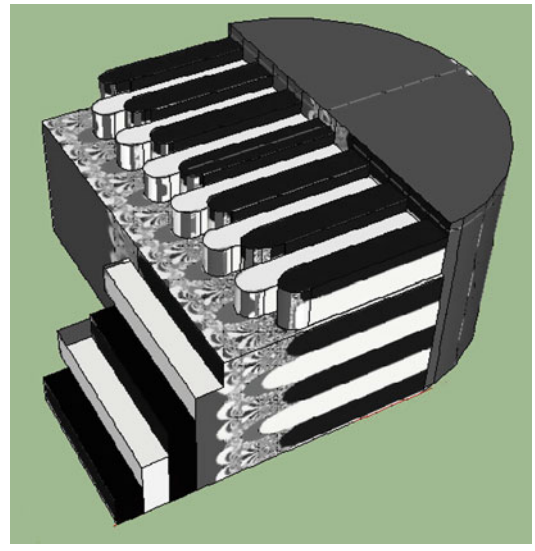


Polynomiography and Innovation, Fig. 5 Polynomiography-inspired drawings by students (Mary K. Battles, *left*), Gina Collins, *right*)

Polynomiography and Innovation, Fig. 6 Polinomio-Calligraphy artwork, combines calligraphy by Ryuji Takaki (http://www.kobe-du.ac.jp/gsdr/takaki/) and corresponding Polynomiography by Bahman Kalantari, 2011

Polynomiography and Innovation, Fig. 7 Virtual sculptor from Polynomiography, jointly with Adrian Sinclair (student)

Polynomiography and Innovation, Fig. 8 Photo of a Polynomiograph of the author that is turned into henna design by Maggie Townsend (student)



Polynomiography and Innovation, Fig. 9 A Polynomiography-inspired sculptor, "Polynomial Piano Playground," created by William Commons (student)

on educational material that could be built around the software technology. Not only could such software be used in several different math classes in K-16 education but in science and art classes as well.

Aside from the above-mentioned educational applications which have actually been studied by a group of MBA student at Rutgers university with profitable forecasts, Polynomiography can be integrated into social media and Smartphone

technology for variety of applications. Polynomiography is a true fusion of math and art, which through its software renders artistic visuals made from polynomials, and words or numbers turned into polynomials. As an entrant into the applications industry, it can be of interest to users on social networking websites such as facebook, as well as users of Smartphones such as the iPhone or other popular technologies. The word "Applications" has been a buzzword in the consumer economy for the last few years. Whether it is the growing population of facebook or the growth in Smartphone users, applications are becoming more and more popular among consumers today. Polynomiography as an application aspires to spread virally on facebook through the youth who have a high need for affiliation and self-expression as well as an interest in new and unique applications. Allowing users to express themselves and their identity in a unique manner, Polynomiography can change any word, message, name, etc., into art that will appear on an individual's profile and be commented upon by all their friends on facebook. This could actually have an appeal across all age groups as it allows the user to quickly generate a unique image that can be shared with their friends. This appeals to the user in that it allows them to convert words and sentences into unique images. Viral buzz also tends to be strong among the young population as those between the 13 and 17 year age group as they are more likely to copy their friends' actions as a "trend" and thus spread an application version of Polynomiography.

The Need for Funding and Support

In order to develop Polynomiography as a successful commercial technology, there is the inevitable need to receive seed funding as well as gaining opportunities that would help develop it and to move forward. Two distinct types of support are necessary: (1) financial support, and (2) developmental support to help bring it to a deserving level of appreciation and utilization in education, art, and more. These include funding to help bring in the needed expertise to develop and maintain a successful software, and to help develop its business aspect. The second level of support includes opportunities to carry out interdisciplinary activities, such as designing lesson plans for teachers, holding training teacher and student workshops, holding exhibitions that would help bring Polynomiography to a wide range of audiences, including children, youth, and the general public.

Fortunately, based on much evidence, including business studies by MBA students in more than one study, Polynomiography can succeed without the need for a large amount of investment. However, the seed money needs to be brought in through national or private agencies. Also, through national science and educational agencies, there is a need to gain grant funding that would allow working with experts to develop interdisciplinary curricula for art, math, and science courses, to hold teacher/student workshops, and to design of new creative educational activities.

Conclusions and Future Directions

There is an inevitable need for a wider appreciation of science and math in the USA. In order to make this happen, there is a need to promote creativity and innovation. This entry has introduced a technology that has the potential to turn polynomials into a very popular, if not a household, word. The technology, called Polynomiography, can lead to new forms of art, and advancements in science, math, and education, and help introduce the public to the deep and ancient subject, rooted in the most significant drive in mankind: solving for the unknown.

With the increasing role of visual tools and technologies, through computer-generated algorithmic visualizations, Polynomiography leverages information technology for the teaching, learning, and promoting of mathematics as a means for inducing striking appreciation of the

connections between creativity in art and the intrinsic beauty of mathematics. Polynomiography has the potential to become a powerful medium for extending the capability of human creative thinking. This capacity needs to be examined in the context of funded pilot projects to lay groundwork for future development and highly collaborative, interdisciplinary research.

The inspirational power of Polynomiography is multifaceted and extends to many domains, including mathematics, the sciences, education, fine arts, and performance arts. Already there are seeds for cultivating interdisciplinary collaborations of different kinds, and the impact of such pilot projects will be to fuel further developments that stimulate creativity and innovative approaches to education that reward creative thinking and problem solving.

However, in order for such a technology to grow as an educational medium, an artistic tool, or a commercial product, there needs to be support of various kinds. These include institutional support, and seed funding to expand its software, to design interdisciplinary activities, to organize exhibitions and workshops in order to bring it to a wide range of audiences, including children, youth, and the general public. These would help bring about a wider appreciation of science and math and inspire new activities.

National government or private agencies that fund science or art projects need to pay more attention to the growth of science and math through interdisciplinary innovations that help combine art, science, and math. In doing so, these agencies need to think outside of the box and to support new and nontraditional avenues of creativity and innovation. At present, these foundations are not spending sufficient funding to promote creative thinking. The USA has one of the strongest programs in higher education in the world, attracting international students from the best universities in numerous countries. However, its expenditure in K-12 education falls short of many countries. This needs to change since according to studies, K-12 students generally do not score as high in science and mathematics as their international counterparts. Risks must be taken and new topics and inventions must make their way into classrooms.

Likewise, institutions such as universities themselves need to promote and support interdisciplinary research that combines art, science, and math and help these subjects grow. It is often believed that there is not enough time to introduce new curricula into old courses, as if curricula are to permanently remain unchanged. There are many reasons to believe that Polynomiography has the potential to enter math, science, and art curricula at many levels, from elementary school classes, all the way up to college level courses.

Cross-References

- ▶ Academic Entrepreneur, Academic Entrepreneurship
- ▶ Angel Investors
- ▶ Antitechnology Movements: Technological Versus Social Innovation
- ▶ Artistic Research
- ▶ Business Start-Up: From Emergence to Development
- ▶ Creative Pedagogy
- ▶ Creativity and Innovation: What Is the Difference?
- ▶ Creativity, Intelligence, and Culture
- ▶ Entrepreneurship Education
- ▶ Experiential Learning and Creativity in Entrepreneurship
- ▶ Freedom and Constraints in Creativity
- ▶ Higher Education and Innovation
- ▶ Imagery and Creativity
- ▶ Innovation by Applied Mathematics
- ▶ Innovations in Geometry
- ▶ Interdisciplinarity and Innovation
- ▶ Interdisciplinary Research (Interdisciplinarity)
- ▶ Invention and Innovation as Creative Problem-Solving Activities
- ▶ Invention Versus Discovery
- ▶ Mathematical Discovery
- ▶ Networks and Scientific Innovation
- ▶ Preparing Students for Learning Through Invention Activities

- ▶ Promoting Student Creativity and Inventiveness in Science and Engineering
- ▶ Science of Creativity
- ▶ Speaking Pictures: Innovation in Fine Arts
- ▶ Start-up
- ▶ Thinking Skills, Development

References

Kalantari B. A new visual art medium: polynomiography. ACM SIGGRAPH Comput Graph Quart. 2004a;38:21–3.
Kalantari B. Polynomiography and applications in art, education, and science. Comput Graph. 2004b;28:417–30.
Kalantari B. Polynomiography: from the fundamental theorem algebra to art. Leonardo. 2005;38(3):233–8.
Kalantari B. Polynomial root-finding and polynomiography. Hackensack: World Scientific; 2008.
Mandelbrot BB. The fractal geometry of nature. New York: W.F. Freeman; 1983.
Mandelbrot BB. Fractals and art for the sake of science. In: Emmer M, editor. The visual mind: art and mathematics. Cambridge: MIT Press; 1993. p. 11–4.

Websites

http://www.cs.rutgers.edu/~kalantar/
www.polynomiography.com

Post-Normal Science

- ▶ Transdisciplinary Research (Transdisciplinarity)

Power-Law Distribution for Innovations

- ▶ Nonlinear Innovations

Preference for Complexity

- ▶ Conflict and Creativity

Preparing a "Creative Revolution" – Arts and Universities of the Arts in the Creative Knowledge Economy

Gerald Bast
University of Applied Arts Vienna,
Vienna, Austria

Synonyms

Aesthetic innovation; Aesthetic research; Re-culturalization of societies; Social design; Societal transformation

Creative Industries or Creative Societies

While in the 1930s, Theodor W. Adorno still was able to say "art is magic – relieved from the lie to be truth," works of the arts more and more are transformed to mere objects of trade. But is not this politically and historically only consistent in an economy-driven society when pieces of art rather have the status of shares at some kind of stock market than artistic statements. Is it really surprising that art dealers change to brokers and art collectors to speculators?

It would be wrong to claim that art would uncouple itself from the social and political relevance. It is rather the *society*, which virtually strategically is going to be depoliticized by increasingly dominant economic structures. Apparently unbiased economic mechanisms take the place of political, cultural, and educational impact parameters in our societies. And this development has not passed by art. How should it? This paradoxically is exactly the evidence of the convexity still existing between art and society. In times when the social and political systems of values are replaced by the shareholder value, when educational contents get degenerated to statistically quantifiable measurements and educational institutions to knowledge-providing factories for the purpose of producing employability to increase economic growth – in such

times it would be more than surprising, if this tendency toward the economization of our society would stop in front of the arts?

Since the late 1980s of the twentieth century, the "invisible hand" of the market increasingly has taken over the steering wheel in the stormy system of the arts and the artists are the rowers – although autonomous rowers. The artists, once depending on religious or secular rulers, became producers for the Creative Industry: galleries, fashion and music labels, training companies, theaters or publishing houses, etc. The artists transform to suppliers for the Creative Industries – and only a few of them succeed in actively influencing the market system by taking over the roles of art producer and bidder at art auctions at the same time – like Damian Hirst did.

Promoting the term "Creative Industries" as a political trademark is a real masterpiece of political strategy, initiated by the Blair government in the UK and then perfectly continued by the institutions of the European Union. In 1997, the UK Creative Industries Task Force was established by the Blair administration.

In 1998, the UK Department for Culture, Media and Sport defined the creative industries as "those industries, that have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property." (Creative Industries Mapping Document 1998).

In the same year, the UK Department for Trade and Industries continued in a White Paper: "In the increasingly global economy of today, we cannot compete in the old way. Capital is mobile, technology can migrate quickly and goods can be made in low cost countries and shipped to developed markets. British business must compete by exploiting capabilities, which its competitors cannot easily match or imitate. These distinctive capabilities are not raw materials, land or access to cheap labor. They must be knowledge, skills and creativity, which help create high productivity business processes and high value goods and services. That is why we will only compete successfully in future if we create an economy that is genuinely knowledge driven" (White Paper 1998, http://webarchive.nationalarchives.gov.uk/20000517080533/http://www.dti.gov.uk/comp/competitive/wh_int1.htm). In 2000, the European Council adopted the so-called Lisbon Strategy. Its aim was to make the EU "the most dynamic and competitive knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010." In 2003, the European Commission demanded: "Europe needs excellence in its universities, to optimize the processes which underpin the knowledge-society and meet the target, set out by the European Council in Lisbon, of becoming *the most competitive and dynamic knowledge-based economy in the world*." (Communication from the Commission – The role of the universities in the Europe of knowledge/* COM/2003/0058final)(http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52003DC0058:EN:HTML).

In 2005, the European Cultural Foundation declared the Creative Sector as an "Engine for Diversity, Growth and Jobs in Europe. The important role of the arts and heritage for the economic development of cities and regions, based on direct and indirect revenues and their employment effects, is of particular importance for regions suffering industrial decline in a post-Fordist age." (The Creative Sector 2005).

And the 2010 document about the EU-flagship Initiative Innovation Union points out clearly again: "Businesses should also be more involved in curricula development and doctoral training so that skills better match industry needs building for instance on the University Business Forum. There are good examples of inter-disciplinary approaches in universities bringing together skills ranging from research to financial and business skills and from creativity and design to intercultural skills. Design is of particular importance and is recognised as a key discipline and activity to bring ideas to the market, transforming them into user-friendly and appealing products." (Brussels 2010).

The strategy was quite sophisticated and multilayered:

1. Tell the cultural sector that it is necessary to stress its effects on economic growth and jobs

to gain a better position in the political decision-making processes.
2. Transform the semantics from Cultural Sector to Creative Industries – thus indicating, that culture now is a part of the industrial sector.
3. Make the members of the former Cultural Sector proud and give them a new feeling of social importance by telling them they would be the new heroes of the society by replacing the weakening old economy.
4. Transform the leading management guidelines of the former cultural sector toward the rationalities of entrepreneurial business administration by implementing a system of mainly quantitative performance indicators for measuring success or failure and for indicating the direction of future development.
5. Express that the mission of the whole Creative Industries Sector is to strengthen the economy and the labor market by providing creativity for innovation.
6. Deplore that cultural activities, which do not have enough short-term quantitative measurable economic effects, cannot have political priority in these hard times.
7. And then declare that Creative Industries is about to become the leading term in cultural policies.

Yes. Cultural industries *are* on the way to become the most important economic sector – especially in urban areas and especially when the leading economic sectors are in trouble. The creative industry does not give a complete image of the system of the arts, not even of the cultural sector, but signs and symbols in communication are important factors – structures and semantics effect habits and minds. So: What does it mean for a musician, a video artist, a poet, and an actor, if he or she is told to be part of the creative industries, because he or she is generating or exploiting intellectual property to earn revenues?

What does it mean for orchestras, dance companies, theaters, art galleries, design-studios, and architects to tell them that their activities are socially justified primarily because they contribute to economic growth and to the stability of the labor market.

What does it mean to art schools if they are told that their existence is socially and economically justified because they contribute to the aim of making Europe the most competitive and dynamic knowledge-based economy in the world?

The mission of art schools is not just to produce human resources for the creative industries, but there would be no art schools if there were no possibilities for graduates to earn money with their artistic skills within the cultural sector. Architects do not plan buildings because they want to support the construction industry – but finally they want to physically realize their plans. Painters do not create their works because they want to increase the economic impact of galleries and museums – but what would happen to all the painters, if there were no galleries, museums, and art fairs? Poets do not write books, because they want to strengthen the printing industry – but what would happen to poets if there were no editors, no printing industry, no theaters, and no broadcasting industry? What would happen to the graphic designers if there was no advertising market? What would happen to the filmmakers if there were no film-industry, no producers, no distributors, and no cinemas?

Creative Industries are not a threat for the arts but the advancement of this term semantically represents the recent social and political developments toward a commercialization of the society quite clearly. The subsectors which are summarized under the term "Creative Industries" of course are important elements of any society. The problem is the hierarchy. Universities are not important, if and because they improve the economy. Culture is not "the heart of knowledge based economy," as the European Cultural Parliament stated (ECP, Lisbon Agenda Research Group 2006). Culture, art, and even science should not primarily be seen as the engine for the vehicle called *economy*, which is moving the society. No, *culture* has to be recognized as the vehicle, which moves the society. And in fact, it *is* like that. To paraphrase Bill Clinton: It is the *culture* stupid! At least in the long run, it is the broad range of culture that matters and that remains in history. Just look at

cultural history: Music, theater, literature, architecture, visual arts, visual communication; changing techniques, and changing media from stone carving to digital media, from affecting human thinking and behavior to recently even manipulating genetic and microbiological material – for centuries, these were and still are some of the most significant factors of human development. Factors caused and influenced by the arts.

The main directions of action, interaction, and mutual influence between societal subsystems in general and between the sociopolitical paradigms of economy and culture are of crucial meaning for the direction of societal development.

Two centuries after the Industrial Revolution and in the middle of the Information Revolution, again standing on societal and economic crossroads, the crucial question now is: Is it possible to make the development as well as the realization of creative ideas and visions the very trademark of our societies? If ever human societies can succeed in turning themselves into creative innovation societies – and for the sake of the future generations, this option undoubtedly must be undertaken! –the next societal and economic revolution will have to be a "creative revolution." Thus, the valences of societal paradigms must be shifted – from a mere commercialization toward a re-culturalization of the society – which in particular demands consequences for the educational and economic systems. Instead of the fabrication of products, the creation of new ideas will have to be the focus point for the shape of educational and economic systems. Therefore, providing creativity will have to be the leading mission of educational systems and creativity must not be a separate sector of the economy (creative industries vs. noncreative industries). Following these principles, the arts in general and art education in particular need to be integrated parts of education and economy as the economy will have to become a creative economy in *total*. Of course, this is a revolution indeed and naturally, the usual arguments can be heard: Regarding the recent nature of industrial companies, the employment structures, and the needs of our population, it is not possible to change the types of the existing economic structures! But similar concerns were raised on the threshold of the beginning industrial age when most of the population was working in and living from agricultural production.

The education system in so-called western societies is still characterized by the spirit of the industrial revolution, whose engines were fragmentation, specialization, and rationalization. Art education and art schools have to be counter-models to this development. Not isolated specialized knowledge is the basis for later success, but creativity, flexibility, the ability to think and act in interdisciplinary and intercultural contexts, questioning existing intellectual as well as behavioral habits arriving at with new scenarios and producing amazement with its own work. Thus, the arts and art schools are indispensable elements of societal infrastructure – at least as important for the development of societies as streets and financial services. The political positioning of the arts and art schools has to be changed from a servant of economic growth toward a leading factor of societal progress, at least in a role of an equal partner to the economy in steering the society!

With industrial-production increasingly moving away from the developed world, creative education will be one major stronghold on the way to securing the economic as well as intellectual and social future. Transformations of the workplace as well as throughout our societies require art-institutes to rethink their societal role and emancipate themselves as crucial players on the way to a creativity-based and innovation-driven future society. On the way toward the highest and competitive aims, not only the so-called western societies will be moving away from industrial, agriculture, and service-based economic structures and increasingly focus on the development of an economy coined by visions, ideas, and a permanent drive for innovation. This new creativity-driven economic model must help to erase the economic structures in place since the Industrial Revolution. Creativity, intellectual flexibility, and innovation must become the very basis of all economic efforts. To meet this aim, significant changes in the educational and economic systems as well as in the

interrelations between education and economy are to be implemented: Creativity and creative skills will have to penetrate the education sector as well as the economic sector in general.

It was at the end of the twentieth century when politics exclaimed the end of utopias. Economic and political pragmatism should dominate and secure the future; feasibility and quantifiability increasingly became the rulers in education and science. Was it really by chance that a few years after proclaiming the end of utopias, after having stopped searching for totally new ideas and paradigms for the future of our social and economic systems, the waves of economic crisis overwhelmed most societies in rapid sequence. With the crisis of the existing market-oriented economic and social system "the chance may arise for a repositioning of the arts as well as art schools within society – not in terms of a re-politicization of art according to historical examples, but rather in the sense of a 're-socialization' of the arts focussing communication and identification." (Bast 2010) Maybe this could be the first step towards a creative revolution.

Of course, it is correct to say that the arts have become massive economic factors and that art education at the universities must refer to practicality and requires contacts, projects, and cooperation with the economic sector – namely the creative economy sector as well. But, at the same time, practicality is not the primary task of universities. Undoubtedly, it seems that the universities and the people connected to them are steadily submitting to economic pragmatism, when in fact, they should be generating the courage to experiment with regard to thought, design, and action: A courage, which – paradox enough – in the final analysis, is also in the interests of economic prosperity. Art schools must be associated more than ever with the development of the arts and the emergence of new artistic approaches, and not be perceived only as places where artistic traditions are passed on, or where students merely prepare for other places outside the art schools where artistic innovation actually happens. In the twenty-first century, the potential for the renewal of art and art education lies in the synergistic coupling and integration of artistic research and art production, aesthetic innovation, and scientific research, preparing artists for the traditional art market as well as for the various means of societal communication.

Conclusion and Future Directions

Art universities and academies will have to decide quickly whether they will continue in the future to be merely a supplier of human capital for the art, architecture, design, music, and theater market, or if they themselves want to claim the organizational rights to the art system and attain effective power: power in terms of fostering, creating and – yes – even defining aesthetic innovation. Of course, such a goal will require not only a change of consciousness, but also a change of contents and structures.

If art universities, in their function as aesthetic research laboratories, are to develop into an effective force beyond the university walls with an impact on the system of arts and on society, if they are to have even more of a social presence when it comes to contemporary art, architecture, and design as well as music, dance, and theater, then the existing institutions must be prepared to expand their traditional roles and spheres of activity. The universities of the arts must seek closer ties with museums and exhibition houses, with activities in the field of urban and social innovation, with theaters and the music industry, as well as connections to current forms and platforms of alternative and popular culture. And art universities must focus on artistic research – much more than they have done so far.

In current social perception, which is colored by the media and politicians, the term "innovation" is more than ever associated with technological and economic progress.

Therefore, the universities of the arts must take care that they do not stumble into an identity trap. The *Zeitgeist*, which dictates that universities – like factories – must also be as efficient and practically oriented as possible, is placing increasing pressure.

Cheaper and quicker output, necessity, need, and economic utility are the dominating

arguments in discussions about universities and art universities in particular. The principal ideas of what is university seem to get paler and paler in present times. Universities do not produce products; they had and still have to generate ideas, attitudes, and perspectives in the hearts and in the brains of people who are enthusiastic enough to meet the challenge of leaving the trodden paths of thinking and acting.

In other words: The output of universities in general and especially of universities of the arts is shaping the future. Therefore, universities of the arts should adopt an offensive and self-confident attitude in the societal competition relating to the definition of progress and, thus, generate courage.

Cross-References

- ▶ Business Creativity
- ▶ Creativity from Design and Innovation Perspectives
- ▶ Entrepreneur in Utopian Thinking
- ▶ Higher Education and Innovation
- ▶ Interdisciplinarity and Innovation

References

Adorno TW. Minima Moralia. Frankfurt a. M.: Suhrkamp, 22. Auflage; 1994, ISBN 3-518-01236-3, S. 298.

Bast G. Designing the future. Against the pragmatism of the useful. An appeal for the resocialization of arts. In: Bast G, Felderer B, editors. Art and now. Wien/New York: Springer; 2010.

Brussels, 6.10.2010 COM(2010) 546 final, Communication from The Commission to the European Parliament, The Council, the European Economic and Social Committee and the Committee of the Regions, Europe 2020. Flagship Initiative Innovation Union, SEC(2010) 1161.

Creative Industries Mapping Document, UK Department for Culture, Media and Sport; 1998.

European Cultural Parliament, Lisbon Agenda Research Group; July 2006.

"The creative sector" – an engine for diversity, growth and jobs in Europe, An overview of research findings and debates prepared for the European Cultural Foundation. By Andreas Wiesand in co-operation with Michael Sondermann, Sep 2005.

The role of the universities in the Europe of knowledge, European Commission, COM/2003/0058final. http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52003. DC0058:EN:HTML.

White Paper "Our competitive future: building the knowledge driven economy". Department for Trade and Industry, UK; 1998.

Preparing Students for Learning Through Invention Activities

James Day
Department of Physics and Astronomy, University of British Columbia, Vancouver, Canada

Introduction

Different forms of instruction are better suited to different learning outcomes. For example, repetition is commonly used for developing motor skills and reinforcement is commonly used for fostering desired attitudes or behaviors. Regardless of the specific pedagogy used, humans generate knowledge and meaning from an interaction between their experiences and their ideas. Many educational settings make it difficult for students to make this connection. For example, some disciplines focus mostly on problem-solving routines, but instruction in problem-solving routines is unlikely to prepare students for many other situations they are likely to encounter. Instead of focusing exclusively on problem-solving techniques, instruction should also focus on students' abilities to learn from new situations and resources. Preparing students for future learning, arguably the greatest educational outcome an instructor could hope to achieve, requires the development of new instructional methods as well as the development of assessments that can reliably evaluate whether or not students have been prepared to learn. One such recent and evolving instructional method is the use of so-called invention activities in the classroom. To quantify the effectiveness of such techniques and subsequently optimize them, an increased emphasis

must be placed on the development of assessments that can reliably measure this very preparedness of a student to learn.

Key Concepts and Definition of Terms

Key Concepts

1. Experts and novices differ in meaningful ways. The study of these differences has revealed important distinctions in how experts learn new ideas and how they organize and apply their existing knowledge. This is important because it provides insight into the nature of thinking and problem solving – specifically, it provides insight into the nature of learning.
2. The transfer of knowledge is a highly desirable and worthy educational outcome. This is an outcome distinct from simply learning new ideas or from applying existing knowledge to the context in which it was taught.
3. Simply providing students with the expert knowledge – whether it be facts, formulas, or other – can be an efficient method of teaching. Often, this efficiency is a shortcut to some final piece of information, the price of which is that students do not develop integrated knowledge structures. It has been demonstrated (Schwartz and Martin 2004) that telling students the expert knowledge is much more effective after the students have investigated the structure of the phenomenon or idea.

Definitions

Expert: Someone with comprehensive knowledge and/or substantial ability in a specific, well-distinguished domain. Being an expert usually translates to being widely recognized as a reliable, authoritative, and credible source of information, technique, or skill.

Transfer: The application by an individual of the skills, abilities, or knowledge acquired in one setting to a second, unfamiliar setting. Neither a clear nor objective demarcation exists between near and far transfer, but attempts have been made to outline a spectrum along which transfer tasks may be placed (Barnett and Ceci 2002).

Invention Activity: An exercise in which students receive a set of carefully selected cases and their task is to invent a compact description of the data that generalizes across the cases. Students do not need to discover the correct answer. Instead, the invention activity helps students to notice important structure in the cases and to form an organizational framework that prepares them to understand conventional descriptions. After the invention activity, students are ready to be told the expert knowledge.

Metacognitive Scaffolding: The provision of support (e.g., in the form of templates, guides, or reflective questions) to promote awareness of learning when concepts and skills are first introduced to students. Such supports can be gradually removed as the student develops autonomous learning strategies.

Theoretical Background and Open-Ended Issue

The study of differences between experts and novices has revealed important distinctions in how they organize and apply their existing knowledge and how they learn new ideas (Ericsson 2006).

People who have developed expertise in particular areas are, by definition, able to think about problems or perform in situations with efficacy in those areas. It is not simply general abilities (such as memory or intelligence, strength or dexterity) that differentiate the expert from the novice nor is it just the application of general strategies. Rather, experts have acquired vast knowledge and experience that affects not only what they notice in their environments but also how they in turn coordinate, constitute, and construe that information. These are the processes that, consequently, affect abilities to recall, reason, and resolve problems or perform tasks. Understanding expertise is important: not because we want to develop our students into experts of any particular discipline, but rather because it provides meaningful insight into the nature of thinking and problem solving.

Numerous examples of how experts differ from novices are outlined in the second chapter of Ref. (Bransford 2000) and include: that experts have well-developed abilities to notice relevant features, structure, or patterns of information in evidence or situations; that experts possess a mental framework for organizing their knowledge that novices lack; that experts' knowledge cannot be reduced to sets of isolated facts or propositions but instead reflects context of applicability; that experts are able to flexibly retrieve important aspects of their knowledge with little attentional effort; and that experts have varying levels of flexibility in their approach to new situations.

The primary goal for educators should be to equip their students with the skills and attitudes that will be of value to them no matter what may be their later path in life. All the same, it is only natural for an instructor to teach under the assumption that their students will continue studying the current discipline being taught (e.g., a physics teacher assumes they are teaching future physicists). So, how does one position novices onto a path to expertise? Verbally communicating the expert knowledge to the students gives the impression of being an efficient way to teach, but it seems so because it is a shortcut. The cost of this shortcut is that students do not develop integrated knowledge structures. This does nothing to progress students towards the expert characteristics listed above. However, the act of telling becomes much more effective if the students have already engaged in investigating the structure of a phenomenon or idea. Instructors must remember that what is an obvious structure for them may not exist for the student. Students will need to investigate this structure on their own. Investigating the structure does not mean solving a series of discrete or step-by-step problems, because students are likely to treat each step as a separate exercise. Instead, instructors can use invention activities as a proven way to get students to explore structure: students receive a set of carefully selected cases, and their task is to invent a compact description that generalizes across the cases. Students do not need to discover the correct answer. Rather, the invention activity helps students notice important structure in the cases and to form an organizational framework that prepares them to understand conventional descriptions. After this invention activity, students can be told the expert knowledge which they will experience as an elegant solution to an authentic problem.

While this approach may help students to learn content, it does not necessarily guarantee that they become more expert-like in their behaviors. A particular question in this regard is: How do we teach better for transfer? The notion of transfer is at the root of our educational system. Teachers want more from learning activities than simply being successful with the lesson at hand, confined geographically and temporally to their classroom. Educators want learning activities that transcend their classroom and benefit their students in the real world. They are hopeful that students will show evidence of transfer in a variety of situations: from one problem to another within a course; from one course to another within the school year; from one school year to the next; and from problems encountered in school to problems encountered in the real world. Even when certain expertise is present, it does not follow that the transfer of particular skills to new situations (termed "adaptive expertise") will result (Bransford 2000). The question of teaching better for transfer remains mostly unanswered. This is in large part because, after decades of intense research activity on the topic of transfer, scholars remain as divided on the issue as they were at its inception. There are some who claim that transfer is exceptionally rare, there are some who state that transfer is increasingly prevalent, and there are some who opine that the situation is plainly unresolvable and that consensus might never be reached. The corpus of scientific knowledge reasonably makes the case that transfer is indeed a salvageable concept (Barnett and Ceci 2002), and some recent evidence suggests that one of the more promising avenues for the improved teaching of transfer is the proper use of invention activities.

Rather than stumbling through the dark in search of other pedagogical techniques for the teaching of transfer, it is worthwhile to focus

our attention to methods that we have already identified as fruitful. In looking under the light, researchers and educators have considered how invention activities could be better delivered. There is good evidence to suggest that transfer is greatly aided by invention (Schwartz and Martin 2004). There also exists evidence that demonstrates how scaffolding these discovery learning activities can boost learning outcomes. Activity scaffolding can occur in a variety of different ways (Lajoie 2005). As some of the loftiest learning goals for introductory university courses involve some form of metacognition (e.g., to have students learn to become better learners), it seems reasonable to complement invention activities with metacognitive scaffolding. Such metacognitive scaffolding might include reflective questioning (does your quantitative final answer run counter to your gut feeling?), structuring the order of operations in a problem (before constructing your analytic solution, first list the properties it should possess), and peer evaluation (have another student critique your solution). Beyond seeming reasonable, this complement of techniques has the benefit of being testable. Researchers can actually measure whether or not students learn content or concepts better and, in principle, whether or not students transfer better when metacognitive scaffolding is built into an invention activity.

The difference between what is possible in principle versus in practice is paramount. How do we measure whether students have improved their transfer skills from invention activities? This question is likely to remain a difficult one for researchers and educators alike. What is needed is that reliable and valid methods of assessment are created to properly measure a students' ability to transfer.

Implications for Theory, Policy, and Practice

The delivery of a learning activity is at least as important as the learning activity itself. Invention activities are no magic bullet and specific care must be taken to ensure that the invention activity is properly delivered. Without proper execution of the activity, students can become frustrated with the activity and both their motivation and their willingness to learn will decrease. In principle, a good invention activity has some rather specific characteristics.

First and foremost, a good invention activity should present a clear and challenging goal to the student – an authentic problem. The goal is often to develop a compact and consistent description or representation of the important features across the given cases. Typically, the description entails integrating multiple features into a single representation, such as a ratio in the simplest case. Examples of these goals could be to find an index for pieces of wood that will allow one to predict whether they will float or sink, or to create a graphical representation that displays the important patterns of an experiment, or to design a cell membrane that allows certain substances to pass through but not others. An appropriate goal is consistent with what an expert does when trying to describe or present novel findings.

The use of contrasting cases in an invention activity is also exceptionally important. Contrasting cases can help novices to notice the distinctive features of each case which they might not otherwise notice (like glasses of wine tasted side by side). An invention activity should comprise multiple cases concurrently, so that students notice both the structure itself and the structural variations across cases that transcend their superficial differences. Ideally, these contrasting cases are made to vary systematically on key parameters, so that students can see how the variations relate at a deeper, structural level. When variables are presented in a confounded way, the contributions of their effects to the parameter under study become significantly more difficult to extract (imagine determining the quality of two wines made from different grapes, served at different temperatures, and paired with different meals). Two to four contrasting cases will provide a reasonable level of difficulty, but a single case can be made to work as well, provided that students will spontaneously generate contrasting cases. If the contrasting cases are structured so that a reasonable but wrong description can be

created by the students (e.g., based on just one or two of the given cases and failing to work for the others), then assurance can be taken in having selected suitable cases.

It is also necessary to be mindful of the context and wording of the invention activity, as well as its level of difficulty. The invention activity should involve material that is relatively familiar and meaningful to the students. When such context is lacking, students might not be able to recognize when a description or representation fails for a given case. (Specific demographics have been observed to stall in the earliest stages of certain activities because of an unfamiliarity with things like pitching machines or pumpkin pies.) The task and cases must make sense to the students. Beyond context but still related to making sense, the invention activity should be worded in a manner which avoids jargon. Use of specialized language can trigger the very common student response of equation-hunting ("What was that formula we learned?"), rather than the desired preparing-to-learn response ("This is a new task!"). For instance, in the example above with the pieces of wood sinking or floating, one should avoid the term density. If students attempt to force some previously learned process or concept upon the task or, worse, if they immediately try to look up the solution, then it should be taken as an indication that language has short-circuited and sabotaged their thinking. That is not to say that recalling familiar concepts should be discouraged, only that the blind use of tangentially related concepts is undesirable. Ironically, this camouflaging of the concept in an authentic problem seeks to prevent (initial) transfer of such tangential concepts and allows students to observe the underlying deep structures. Concerning level of difficulty, students should have partial success and not be expected to come up with the solution that covers all cases and took experts centuries to discover. If one is interested in teaching complex ideas, multiple activities should be used that are each limited in scope. To this end, each activity should be used to introduce one or two new structural parameters. If the students are able to get started but seldom find the perfect/complete answer, then the invention activity probably has an appropriate level of difficulty.

Invention activities work best when attempted by pairs (or small groups) of students and so should be completed collaboratively. By explaining to their partners how they have reached a conclusion requires of the student an analysis of their own thought processes; conveying these ideas to others helps deepen their understanding because the student has to explain it in a manner that their peers can also understand. In this way, small group work fosters deep learning. Furthermore, establishing meaning and understanding through presentation to others aids in memory encoding, storage retention, and retrieval.

The structure of the invention activity should not allow for students to be able to divide up the task and work independently; rather, the classroom should be filled with exchanges similar to "But would that method work for this case?" or "Does this solution make qualitative sense?"

Finally, authors of invention activities should anticipate a design cycle. Ideally, one should field-test the activity with a few representative students first and modify as needed before using it with a class. Realistically, modifications are typically made to the following year's class based on what was learned in the previous year. If, when completing the invention activity, students slowly begin to notice and try to represent the key structures that an expert can see easily in the cases, then the invention activity is probably in suitably functional form.

An example of a simple invention activity is shown in Fig. 1. The premise of this invention activity is that students will be better prepared to understand the formula for standard deviation when first afforded an opportunity to differentiate the elements of variability for which the formula must account. Working in small groups, the students try to generate a formula that accounts for all the given quantitative properties (e.g., dispersion or sample size). At the end of the exercises, students should be shown the variability formula used by experts. Other explicit examples of effective invention activities which precede direct

Preparing Students for Learning Through Invention Activities, Fig. 1 A sample invention activity, in the domain of statistics (Modified from data published in Bransford and Schwartz (1999))

Pat, Alex, Chris, and Lee are all members of the Little City Basketball Team. After five games of the regular season, the four begin contemplating their offensive contributions to the team.The table below shows how many points have been scored by each player per game.

Player	Game 1	Game 2	Game 3	Game 4	Game 5
Pat	6	4	8	10	2
Alex	6	5	7	8	4
Chris	10	2	10	10	2
Lee	14	-	8	12	-

Goal: Create one or more mathematical formulas that summarize how each player tends to score in a game.

instruction can be found, for example, for the case of teaching variability in data and the difference between accuracy and precision (Schwartz and Martin 2004) and for the case of creating histograms and calculating standard deviation (Day et al. 2010).

The main purpose of an invention activity is to prime students for learning; therefore, direct instruction must follow the invention activity. Upon detecting the important structure in the cases, students are better able to build an organizational framework that prepares them to understand the conventional description then presented by the instructor – the "elegant solution" to an authentic problem.

The potential benefits of an invention activity are nearly completely lost if this final step is not taken. Conversely, great outcomes can result from proper execution. For example, in a sequence of design experiments on the teaching of descriptive statistics, Schwartz and Martin (2004) demonstrated the effectiveness of invention activities when they preceded direct instruction, even though these students failed to produce canonical conceptions and solutions during the invention phase. In this study, it was observed that invention activities, when coupled with subsequent learning resources like lectures, led to strong gains in procedural skills, insight into formulas, and abilities to evaluate data from an argument. Most importantly, invention activities were found to significantly boost students' future learning, when compared against direct instruction (simple "tell-and-practice") alone.

Conclusion and Future Directions

There is a growing body of literature demonstrating the existence of benefits derived from invention activities on present and future learning. An apparent relationship between failure and mental frameworks forms a common thread through many of the diverse research programs investigating how students learn. The central findings of these research programs can collectively be interpreted as an argument for the delay of structure in learning and problem-solving situations, be it in the form of feedback and explanations, coherence in texts, or direct instruction. The convergence of evidence is pointing to the efficacy of learner-generated processing, conceptions, and understandings, even though such conceptions and understandings may, in the shorter term, not be correct and the process of arriving at them not as expeditious.

One future direction is to deliver these activities with computer-based intelligent tutoring systems. These are used to coach students while they are problem-solving. While intelligent tutoring systems offer sufficient support with proven learning gains, the tasks they facilitate (e.g., basic descriptive statistics or simple graphical representations) are relatively constrained and do not require students to practice their inquiry and scientific reasoning and learning skills. One recent step in this direction has been termed the Invention Lab (Roll et al. 2010), which is an environment that complements the benefits of constructivist tasks (e.g., quantifying the spread of data about the mean of its set) with adaptive

support (e.g., an algorithm that generates contrasting cases on the fly). The Invention Lab facilitates invention activities that are structured, more or less, as outlined above by an ex tempore analysis of students' inventions and subsequent creation of new problems to match the perceived gaps in their understanding. In so doing, the Invention Lab offers support without reducing critical elements of the constructivist activity. More recently, these ideas have been extended even further. There exists a computer-based interactive learning environment, called the Invention Support Environment (Holmes 2011), that was built to both improve the in-class use of invention activities and act as a research tool for studying the effects of these activities (for the case of scaffolding relatively complex learning (Reiser 2004), what role does domain-general scaffolding of invention activities play in supporting the acquisition of domain knowledge and of scientific reasoning skills?). The system was designed to support various levels of domain-general scaffolding, as well as invention and reasoning skills. The system also features a platform for which new invention activities may be created and requires minimal programming experience (if any).

A salient characteristic of many research studies usually involves the use of a final transfer task in a "sequestered problem-solving" (SPS) way. In other words, the subjects are isolated while working on the transfer task so that they do not have opportunities to invoke support from other resources (e.g., texts or peers) nor may attempt various solutions, receive feedback, or revise their work. Along with the SPS paradigm is the conception that effectively defines transfer as the ability to directly apply (DA) one's previous learning to a new setting or problem. Of course, there exist alternatives to the union of SPS methodology and DA theory. One such alternative is the approach that appreciates the validity of the SPS/DA position but also extends the concept of transfer by introducing an emphasis on the student's "preparation for future learning" (PFL). In the PFL model, the focus shifts from sequestered tasks to assessments of the student's abilities to learn in knowledge-rich environments and from single-shot task performance to extended learning. The better prepared a student is for future learning, the greater will be the transfer (in terms of speed and/or quality of new learning). So, what does this mean for how research on transfer might look in the future? From the PFL perspective (Bransford and Schwartz 1999), it means that assessments of people's abilities can be improved by moving from static (single-shot, summative testing) to dynamic assessments (environments that provide opportunities for new learning). What one currently knows is clearly important for future learning – this new perspective further proposes the hypothesis that a dynamic assessment of a student's ability to learn over an extended period might better predict that student's success "in the end" than a single-shot SPS test at the beginning. This is a major challenge for future research.

Cross-References

- ▶ Adaptive Creativity and Innovative Creativity
- ▶ Analogies and Analogical Reasoning in Invention
- ▶ Creative Problem Solving
- ▶ Invention Versus Discovery
- ▶ Scientific Inventive Thinking Skills in Children
- ▶ Strategic Thinking and Creative Invention
- ▶ Teaching as Invention
- ▶ Teaching Creativity
- ▶ Thinking Skills, Development

References

Barnett SM, Ceci SJ. When and where do we apply what we learn? A taxonomy for far transfer. Psychol Bull. 2002;128:612–37.

Bransford JD. How people learn: brain, mind, experience, and school. Washington, DC: National Academy Press; 2000.

Bransford JD, Schwartz DL. Rethinking transfer: a simple proposal with multiple implications. Rev Res Educ. 1999;24:61–100.

Day J, Nakahara H, Bonn D. Teaching standard deviation by building from student invention. Phys Teach. 2010;48(8):546–8.

Ericsson KA. The Cambridge handbook of expertise and expert performance. Cambridge: Cambridge University Press; 2006.
Holmes NG. The invention support environment: using metacognitive scaffolding and interactive learning environments to improve learning from invention (thesis). Vancouver (BC): University of British Columbia; 2011.
Lajoie SP. Extending the scaffolding metaphor. Instr Sci. 2005;33:541–57.
Reiser BJ. Scaffolding complex learning: the mechanisms of structuring and problematizing student work. J Learn Sci. 2004;13(3):273–304.
Roll I, Aleven V, Koedinger KR, et al. The invention lab: using a hybrid of model tracing and constraint-based modeling to offer intelligent support in inquiry environments. In: Aleven V, Kay J, Mostow J, editors. Proceedings of the international conference on intelligent tutoring systems. Berlin: Springer; 2010. p. 115–24.
Schwartz DL, Martin T. Inventing to prepare for future learning: the hidden efficiency of encouraging original student production in statistics instruction. Cogn Instr. 2004;22(2):129–84.

Pretend Play

► Imagination

Pretense

► Imagination

Principal–Agent Model in Universities, Problems and Solutions

Andreas Panagopoulos
University of Crete, Rethymnon, Greece

Synonyms

Agency dilemma; Lack of disclosure

Introduction

The modern day university acts as a powerhouse of indirect economic activity that stems from the scientific discoveries, inventions, and innovations that university scientists develop. Bearing in mind that it is hard to assess the potential of novel discoveries, the university is facing the so-called principal–agent problem in the way it incentivizes the research of faculty members.

Definition of the Principal–Agent Problem

The principal–agent problem (henceforth PA problem), which is also known as the agency dilemma, concerns the difficulties in motivating one party (the agent), to act on behalf of another (the principal). In universities, the PA problem is manifested in (1) the way the university motivates faculty research and (2) in the way the university motivates disclosure of faculty inventions to the university Technology Transfer Office (TTO), which is also known as Technology Licensing Office (TLO). The role of the TTO is to act as a technology-transferring mechanism that allows the university to profit by assigning the rights of faculty-made scientific discoveries to a third party.

The Principal–Agent Problem in Motivating Faculty Research

In terms of motivating faculty research, universities rely on the so-called peer-review system, where peer review is a process of evaluation involving qualified individuals within the relevant field. Accordingly, faculty members are rewarded (in terms of tenure or promotion) depending on how many journal publications they amass in journals that follow the peer-review system. Furthermore, reward depends on the quality of the peer-reviewed journal per se, as well as on how many citations such publications stockpile. In effect, the university outsources the solution of its PA problem to independent scientific journals. Thus, it is up to these journals (which usually lack formal ties with the university) to determine what is published and where, and it is up to the readers of such journals to cite the published work or not.

Consequently, with little effort, the university has at hand a cardinal measure of faculty quality on which to base its decisions.

The Principal–Agent Problem in Motivating Disclosure of Faculty Inventions

The facts of university technology transfer are, in theory, surprisingly simple. Upon invention the faculty scientist is obliged to disclose her invention to the TTO, and the TTO must then try to assign the rights of the said inventions to a third party. In this manner the university can derive pecuniary benefits that are then shared with the faculty scientist. Unfortunately, in practice, university technology transfer is not as simple, and only a subset of all faculty inventions are disclosed to the TTO. In fact, as Markman et al. (2007) show, high-valued inventions are never disclosed, leading to a considerable loss of profits for the university. This is not surprising as the benefits accruing to faculty scientists upon disclosure are commonly in the range of 30 % of licensing proceeds, with the university keeping the rest.

It has been argued that the solution to such unwillingness to disclose is a simple reallocation of proceeds. As Thursby and Thursby (2004) note, disclosure is linked to the pecuniary rewards that faculty attains from licensing. Therefore, as suggested by Lach and Schankerman (2004), disclosure can be achieved by shifting the distribution of licensing proceeds in favor of faculty members. This seems easier said than done. In fact, as Markman et al. (2012) display, high-valued inventions will only be disclosed to the TTO if the scientists effectively free-ride, attaining 100 % of the licensing proceeds, in which case the university is left with naught.

Notwithstanding the above, as TTOs have been accused of failing to attract quality licensees (further worsening the lack of disclosure), the distribution of proceeds is but one of the problems plaguing faculty disclosure. In illustrating this point, Markman et al. (2005a) find that TTOs are extremely risk-averse and follow suboptimal licensing strategies focusing on short-term cash maximization. Along these lines, Siegel et al. (2004) present evidence indicating that TTOs appear to do a better job in serving the needs of large established firms, instead of small entrepreneurial firms; even though it is the latter who usually have a greater capacity for adding value to the invention.

In addition, Siegel et al. (2003a) find that informational/cultural barriers exist between TTOs and small firms. This argument is in line with Markman et al. (2005b) who focus on the bureaucratic nature of TTOs. As they argue the bureaucratic nature of TTOs creates barriers for disclosure. This observation is in agreement with Siegel et al. (2003a), and Siegel et al. (2003, 2004) who suggest that the key obstacles to effective university technology transfer seem organizational in nature. As they note, university technology transfer is obstructed by differences in organizational cultures between universities and firms (especially smaller firms), incentive structures, and staffing/compensation practices followed by TTOs.

Solving Principal–Agent Problem in Motivating Disclosure of Faculty Inventions

The main solution used so far is monitoring, which as Markman et al. (2012) display has thus far provided limited results because it is difficult to prosecute academic personnel failing to abide with the TTO's objectives. It stands to reason that the optimal solution to the PA problem would be one that allows faculty scientists a free hand in dealing with their inventions, while fully informing the TTO of their actions, allowing the university to appropriate part of the proceeds. Panagopoulos and Carayannis (forthcoming) formulate such a solution.

As Panagopoulos and Carayannis (forthcoming) display, by altering the TTO's role, from a monitoring office that licenses/transfers university technology to an office that offers faculty scientists some form of "insurance" that guarantees them a positive return if/when they have

failed to license their technology (on their own), full disclosure can be achieved. Furthermore, this "insurance" does not have to be pecuniary. In fact, it can take the form of extra brownie points (or any other form of social currency) in appreciation for the faculty scientist's (important yet unlicensed) research. Such a focus on nonpecuniary incentives is in line with Hayter (2011) who suggests that faculty scientists do not solemnly define success in terms of monetary gains and can be also motivated by peer recognition or the choice of public service.

The rationale behind this proposal rests on the following principle. Consider an agent who is bargaining with another party on how to split some value. If this agent is left destitute upon failing to negotiate an agreement, she is obliged to bargain with her back against the wall, accepting even suboptimal arrangements. By contrast, the same agent should expect a better bargaining outcome when she bargains having something to rely on (i.e., a positive outside option) just in case bargaining fails.

The above example suggests that in licensing negotiations by pumping up an agent's outside option, she can expect a better bargaining outcome. The implication of this reasoning is that a faculty scientist (who aims to negotiate her own licensing deal with a perspective licensee) should be willing to disclose her invention to the TTO in order to be granted the aforementioned outside option. All that is needed for achieving disclosure is for the TTO to charge a price (i.e., the licensing proceeds that the university keeps) that does not exceed the additional benefits accruing to the scientist because of this outside option.

Taking a Closer Look at This Policy

Following Binmore (1992, pp. 189–191), cooperative game theory suggests that bargaining can be modeled, via a technique known as Nash bargaining, by using the so-called Nash product. This product accounts for how two parties split up a certain value they are bargaining on depending (1) on how much each party gets if bargaining is fruitful and (2) on one's outside option if bargaining fails. In terms of point (2), maximizing the Nash product (in order to find the optimal bargaining share of each party) immediately lays the argument bare.

Specifically, the bargaining share that accrues to the faculty scientist must always be a positive function of her outside option. In brief, by increasing this outside option the faculty scientist stands to gain a greater share from splitting the value of the technology she is trying to license. The intuition behind this point is almost elementary as it suggests that agents who do not have much to lose can barter a better deal compared to agents who face a negative outcome upon failure and are thus inclined to accept even suboptimal bargaining shares.

As a result, since her share of the licensing fees increases, the faculty scientist should be willing to pay for such an outside option (the abovementioned "insurance") by disclosing her technology to the TTO, allowing the TTO to charge a fee for its services. Consequently, all that is needed to achieve full disclosure is for the TTO to offer some "insurance" that does not exceed the pecuniary benefits accruing to the faculty scientist because of this additional outside option that she enjoys. In determining the value of this "insurance," as well as the TTO's share of the proceeds, one must compare the faculty scientist's payoff from licensing in the absence of such a scheme with the payoff she derives by disclosing her technology to the TTO in exchange for the said "insurance."

For this scheme to work, two are the important parameters that if calibrated correctly can lead to full disclosure for all types of inventions, (1) the value of the "insurance" and (2) the share of licensing fees that accrue to the TTO upon disclosure. Nevertheless, a few interesting points can be immediately differed from the above discussion. Specifically, as Panagopoulos and Carayannis (forthcoming) note, since an increase in the university's "insurance" policy increases the bargaining share of the faculty scientist, in principle the university could charge a greater fee for such a service by appropriating a greater share of the scientist's licensing fees.

In a nutshell, the TTOs share of the proceeds must be positively related to this "insurance."

Conclusion and Future Directions

This policy is effectively a forward looking policy that aims to solve the problem before it emerges. Furthermore, by solving the problem of disclosure this policy further promotes technology transfer, speeding up the innovation process. In this respect, this method adds to a well-established arsenal of incentives that promote innovation, an arsenal that includes patents and prizes as incentive mechanisms. However, prizes and patents do not address the PA problem. In this fashion, the incentive mechanism described here shares some common aspects with the Phoenix Awards, pioneered by the Economic Development Board (EDB) of Singapore. Specifically, since 2000 the Phoenix Award "*seeks to acknowledge technology-related entrepreneurs who have weathered the storm prior to success.*" For this award, which seems to be largely dormant at the moment, nominees are evaluated on the way they managed to overcome past business failures prior to finding success using technology. Since the Phoenix Award is backward looking, taking place after the inventor has failed to implement her technology, it is not directly comparable to the "insurance" described here. Nevertheless, the way the award has been structured (and the process used in deciding who gets the award) could offer some important insights on how to accurately come to a decision on the magnitude of the "insurance" that each individual faculty member may require.

Cross-References

- ▶ Academic Entrepreneur, Academic Entrepreneurship
- ▶ Academic Entrepreneurship
- ▶ Game Theory and Innovation Analysis
- ▶ Higher Education and Innovation
- ▶ Patents and Entrepreneurship
- ▶ University Research and Innovation

References

Binmore K. Fun and games. Toronto: D.C. Heath and Company; 1992.

Hayter C. In search of the profit-maximizing actor: motivations and definitions of success from nascent academic entrepreneurs. J Technol Transf. 2011;36:340–52.

Lach S, Schankerman M. Royalty sharing and technology transfer in universities. J Eur Econ Assoc. 2004;2:252–64.

Markman G, Balkin D, Phan P, Gianiodis P. Entrepreneurship and university-based technology transfer. J Bus Ventur. 2005a;20:241–63.

Markman G, Gianiodis P, Phan P, Balkin D. Innovation speed: transferring university technology to market. Res Policy. 2005b;34:1058–75.

Markman G, Panagopoulos A, Gianiodis P. Scientists or entrepreneurs: rent (mis)appropriation from discoveries made in university labs. Best Paper Proceedings of the American Academy of Management, 2007.

Markman G, Gianodis P, Panagopoulos A. Opportunistic behavior in research organizations. Best paper proceedings of the American academy of management (2012)

Panagopoulos A, Carayannis E. A policy for enhancing the disclosure of university faculty invention. J Technol Transf. (forthcoming).

Siegel D, Waldman D, Link A. Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study. Res Policy. 2003a;32:27–48.

Siegel D, Waldman D, Atwater L, Link A. Commercial knowledge transfer from universities to firms: improving the effectiveness of university-industry collaboration. J High Technol Manage Res. 2003b;14:111–33.

Siegel D, Waldman D, Atwater L, Link A. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. J Eng Technol Manag. 2004;21:115–42.

Thursby J, Thursby M. Are faculty critical? Their role in university licensing. Contemp Econ Policy. 2004;22:162–78.

Private Equity

- ▶ Venture Capital and Small Business

Problem Finding

► Four Ps of Creativity and Recent Updates

Problem Solving

► Creativity: Cultural Capital in Mathematics
► Four Ps of Creativity and Recent Updates

Problem Solving by Wisdom

► Method for Creating Wisdom from Knowledge

Problem-Solving

► Creativity in Invention, Theories

Procedural Modeling

► Imagination

Process Excellence

► Six Sigma

Product Development

► Product Development, Business Concept, and Entrepreneurship

Product Development, Business Concept, and Entrepreneurship

Laure Morel[1], Mauricio Camargo[1] and Vincent Boly[2]
[1]ERPI, University of Lorraine, Nancy, France
[2]Equipe de recherche sur les processus innovatifs (ERPI), Université de Lorraine, Nancy, France

Synonyms

Business model; Idea generation; Opportunity; Product development

Nowadays, fierce competition and industry relocation toward developing countries, entrepreneurship, and innovation are widely recognized as key factors in competitiveness. The shortening of the product life cycle (products and services), the need to differentiate from competitors and reduce manufacturing costs, and effective logistics and marketing are all reasons to create and develop innovations to meet these challenges. For many countries, the private sector and entrepreneurship have been a powerful engine of economic growth and wealth creation. The formation of new businesses leads to job creation and has a multiplying effect on the economy. Socially, entrepreneurship empowers citizens, generates innovation, and changes mindsets. To that effect, studying the processes that lead an entrepreneur to look for new business concepts and then new product development processes is central to the innovation dynamics.

Entrepreneur Abilities

The most well-known definition of an *entrepreneur* is that of Schumpeter (1934). Indeed, since the 1930s, he has argued that the role of the entrepreneur is essential for economic dynamics and that the individual entrepreneur is the real source of innovation. He said that an entrepreneur

is not considered as an inventor, but seems to have a particular momentum, a sense of authority and challenge enabling him to achieve a *new combination* of factors. However, it should be noted that the concept of producing a *new combination* has been somewhat questioned by Perroux (1951) who emphasizes the vagueness of the role of the entrepreneur in the Schumpeterian definition. "A comprehensive analysis of this concept leads ineluctably to the recognition that it denotes a series of separate operations. To achieve the full meaning of the term *new combination*, it must incorporate not only the principle design, assess its implementation plan, decide on the execution, overcome resistance, or raise capital and skills but also agree to take on the production risks permanently. The latter agreement, the latter act, is decisive. Until it is done, all the others remain futile." In other words, the entrepreneur's role is to transform the idea into reality, allowing us to consider innovation as "creativity in action" or the opening up of new areas of design. Indeed, innovation allows the exploration of new areas of knowledge, unsuspected at first, which results in opening up realms of possibilities and the introduction of a high degree of variability into the innovation process (Smith 1996).

The result is, in fact, a higher level of risk to be managed by taking into account a global, systemic approach incorporating information from the environment that has an impact on the process of creating a new business.

Consequently, new methods and skills are needed to enable entrepreneurs to identify opportunities at any time, leading to the integration of a "constructivist" process of thinking (Smith 1996).

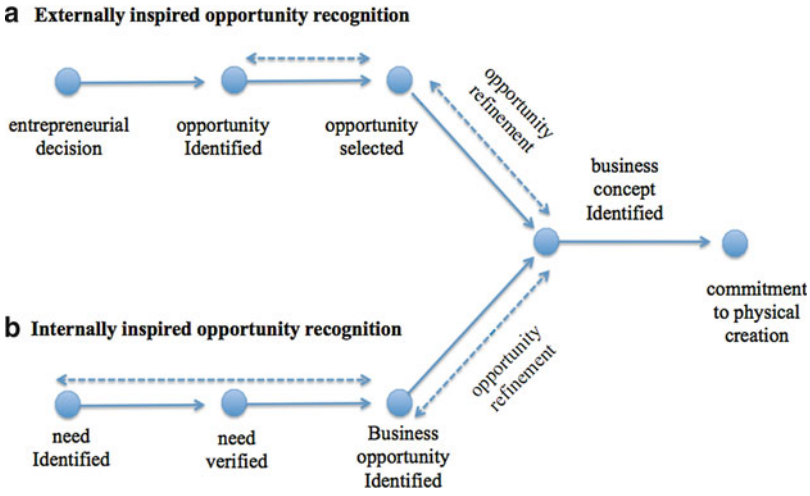
Business Concept and Entrepreneurship

Based on the fact that every business concept has its origin in the ability of the entrepreneur to generate an idea, Bhave (1994) has formalized the existence of opposition in the mind of the entrepreneur at the time of the creative spark, recalling the well-known paradox of the chicken and the egg. Is it the idea or the desire to create a new business which comes first? The author demonstrates that if entrepreneurial desire precedes the identification of an idea, the business process is generated by identifying, selecting, and adjusting an opportunity that becomes a business concept (A). A second case occurs when the creative spark is the identification of a particular need. In this case, the need has to be verified before the business opportunity is identified (B). In both cases, adjustments to the opportunity are formalized in a business concept.

So, the creation of a new business with development potential must satisfy a specific need to claim to become a success. The business concept includes the clear identification and formalization of the unsatisfied need that the new product will provide. For example, how this "product" is new or better than existing ones or what is the unserved market to which it will respond. For Minniti and Bygrave (2001), an entrepreneur's decisions are the result of two types of knowledge: the first from information about market conditions, business opportunities, technologies, or new ideas and the second related to his/her personal experiences, capabilities, and skills as entrepreneur.

The origin of the information used to make decisions is twofold: the entrepreneur's previous experience and beliefs and new information resulting from the formalization phase of the project. The research study by Parker (2006) has shown that on average, these individuals adjust their expectations of unobserved productivity in the light of new information by only 16%. This suggests that while entrepreneurs do exploit new information, they give much greater weight to their prior beliefs when forming their expectations. So the "business concept" appears to be largely predetermined. He also found that, among other things, the age of the entrepreneur and cultural factors significantly alter the influence new information has on decisions (the young entrepreneur seems more receptive to external information because of his reduced feedback or expertise).

Furthermore, it appears that the process of ideation is the result of exchange and confrontation between two spaces of exploration and exploitation. While the first is based on the



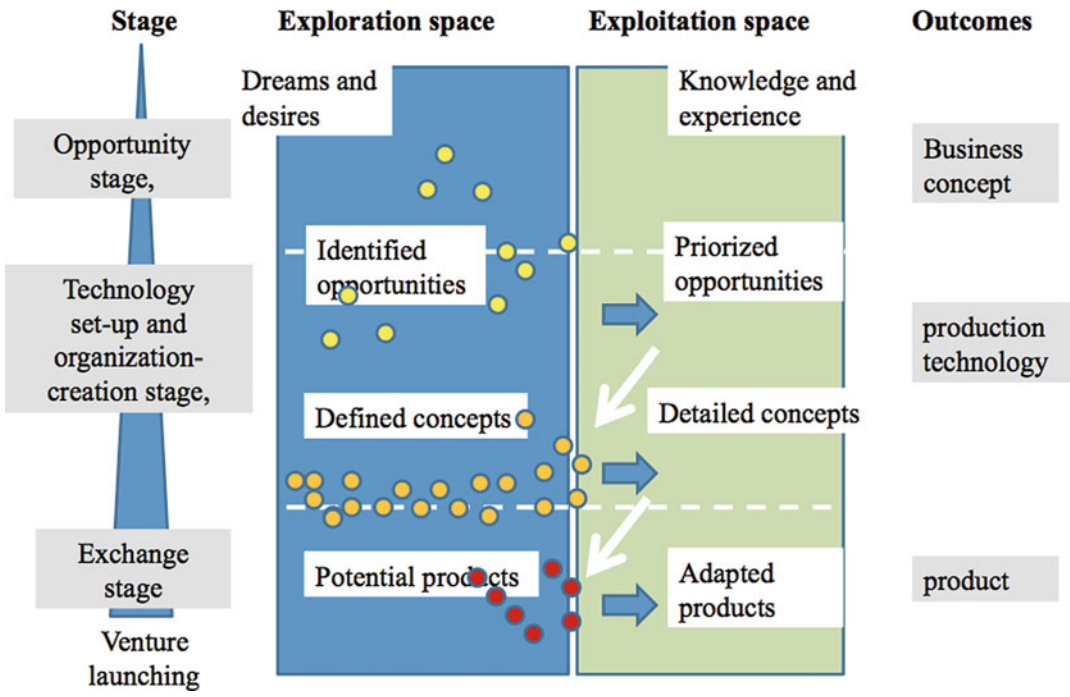
Product Development, Business Concept, and Entrepreneurship, Fig. 1 Opportunity recognition stage in the venture creation process (Source: Adapted from Bhave 1994)

entrepreneur's ability to dream and move forward from his current knowledge and skills leading to innovation, the second reflects a desire to work more in his comfort zone that is based primarily on concepts and processes which are well known and mastered.

Figure 2 shows an overview of the exchange process between the two areas described above. Originally, the model included seven stages (internally and externally stimulated opportunity recognition, commitment to physical creation, production technology setup, organization creation, product creation, connecting to markets, and customer feedback), but for analytical convenience, the author divided the process into three stages: the opportunity stage, the technology setup and organization creation stage, and the exchange stage. Note that the business concept, production technology, and product are the core variables representing the three stages respectively:

- *Opportunity recognition*: This stage includes the process described in Fig. 1, starting from the preparation (internally or externally inspired opportunity recognition) and incubation of the idea through an intuitive non-intentional thinking process allowing the consideration of possibilities or options to solve a problem. This stage ends with the insight (eureka, aha!) and occurs when the entrepreneur consciously realizes that the idea may represent an entrepreneurial opportunity and how it could create value. The main outcome of this stage is the business concept.
- *Technology setup and organization creation*: This involves the tangible actions needed to create an organization, a production technology, a product or service, as well as the first customer contacts. Also, the original idea is further refined toward a more detailed business concept, a practical commitment to actually realizing the idea, and implementing this realization. At the end of this stage, the organization and production technologies are not only defined but the emerging product concept is also evaluated with other people in the entrepreneur's networks.
- *Exchange*: This involves connecting to markets and customer feedback. At this stage, even if the venture has been launched, the product concept and the organization structure must be continually evaluated and adapted from customer feedback until final product definition. There is a growing trend of incorporating latent customer needs as soon as possible in order to reduce the risks inherent to introducing innovation onto the market. A comprehensive analysis of these approaches is made in Ben Rejeb et al. (2011).

In summary, the process of venture creation is a recursive process. Indeed, as pointed out by



Product Development, Business Concept, and Entrepreneurship, Fig. 2 Dynamics of the entrepreneurship process (Source: Our research)

Lumpkin et al. (2004), although the components of the process have been called "stages" here, it is important to note that they are not necessarily linear and may not follow any predetermined sequence.

Business Model and Entrepreneurship

Two schools of thought coexist in entrepreneurship: researchers who argue that a systematic plan and clear business model need to be produced upstream, leading to better performance of the future business, and others who advocate that the entrepreneur's learning ability, flexibility, and strategic management resources are the factors most critical to success, especially in uncertain environments. Furthermore, in a comprehensive literature study using meta-analysis, Brinckmann et al. (2010) reviewed 50 studies in order to explore the effects of a priori planning of the business model on the performance of small businesses already created and entrepreneurial projects. There were two major conclusions:

- First, the positive impact of a priori planning is greater among businesses already established, thanks to their prior knowledge of the industrial sector and information collected about the innovation project to be launched.
- Then, in the case of an entrepreneurial project, basic non-exhaustive planning is enough to start the project. Success will be conditioned by the reliability, quality, and quantity of information gathered and by events requiring the entrepreneur's learning ability and flexibility.

Based on the observation of many several innovation and entrepreneurship projects, a conclusion could be certainly made: the earliest materialization of the idea in product development and the iterative nature of its fine-tuning have a decisive role in defining the business concept to be validated. As previously mentioned, the business concept will be translated paying particular attention to customer definition, the

value proposition and compelling story, the product/service proposal, and the identification of the distribution and commercialization process resulting in the development of the most suitable business model. Nevertheless, the choice of business to be undertaken remains complicated. Indeed, the entrepreneur will change back and forth along a path of possibilities from the development of an activity by incremental innovation, which is thus less risky, or focusing his choice on disruptive innovation that, even while it may have more associated risk, can bring the greatest benefits. But this is part of that could be called the "entrepreneur dilemma."

Conclusions and Future Directions

The increasing need to minimize risk and validate the relevance of a concept has led the research into new ways to integrate the customer into the development process as early as possible in order to reduce the uncertainty of the business model definition. In recent years, emerging approaches have appeared based on the open-innovation paradigm, for example, the living labs.

Living labs are innovation environments where stakeholders form a partnership of entrepreneurs, users, public agencies, and research organizations. Cooperation is established for creating, prototyping, and using new products and services in real-life environments. Users are not seen as subjects for innovation and customers, but as early stage contributors and innovators (Følstad 2008). The living labs can therefore be seen as user-driven open-innovation environments with the following features:

Users' integration: In a LL approach, users are considered as cocreators and not simply as observed subjects. In practice, the goal is to increase the degree of user involvement during the product development process. The difficult aspect in this approach is to make users express their preferences consciously.

Interdisciplinary (between partners and users): According to the open-innovation principle, the interdisciplinary approach helps to increase creativity. The interdisciplinary approach allows specifications to be formulated so as to create and develop a product better suited to users' needs.

Experimentation in a real-life context: Taking into account the context for use can have a significant influence on the product's use. The experimentation step is essential for evaluating the potential acceptance/adoption of the product (good, service, application, etc.).

Almirall et al. (2009) defined the implications of involving users as codevelopers under the living lab model for entrepreneurship and more precisely for business concept definition as:

- A reduction in personal entrepreneurial risk
- Support for entrepreneurship through selecting, coordinating, and funding assistance for the innovation network
- The creation of an innovation arena where experimentation can take place
- Fostering an initial demand allowing further development

Indeed, innovation is gradually being perceived, from a systemic viewpoint, as the result of increasingly large groups that were represented first as teams and, later, as networks and communities, leading to an understanding of innovation as an emerging open process based on collaboration and discussion.

Cross-References

- ▶ Creative Management
- ▶ Entrepreneur
- ▶ Entrepreneurial Opportunities
- ▶ Environmental Determinants of Entrepreneurship
- ▶ Ideas and Ideation
- ▶ Risk, Uncertainty, and Business Creation

References

Almirall E, Wareham J. The entrepreneurial role of living labs in closing the gap between research and innovation. eChallenges 2009, October 21–23, 2009. Istanbul, Turkey; 2009.

Ben RH, Boly V, Morel-Guimaraes L. Attractive quality for requirement assessment during the front-end of innovation. TQM J. 2011;23(2):216–34.

Bhave MP. A process model of entrepreneurial venture creation. J Business Venturing. 1994;9:223–42.
Brinckmann J, Grichnik D, Kapsa D. Should entrepreneurs plan or just storm the castle? A meta-analysis on contextual factors impacting the business planning–performance relationship in small firms. J Business Venturing. 2010;25:24–40.
Følstad A. Living labs for innovation and development of information and communication technology: a literature review. eJOV-Vol.10. Electronic J Virtual Org Networks. 2008;10:99–131. ISSN: 1442–9331, www.ejov.org.
Lumpkin G, Hills G, Shrader R. Opportunity recognition. In: Welsch HP, editor. Entrepreneurship the way ahead. New York: Routledge; 2004. p. 73–90.
Minniti M, Bygrave W. A dynamic model of entrepreneurial learning. Entrepreneurship Theory Practice. 2001;25:5–16.
Parker S. Learning about the unknown: how fast do entrepreneurs adjust their beliefs? J Business Venturing. 2006;21:1–26.
Perroux F. Les trois analyses de l'évolution et la recherche d'une dynamique totale chez Joseph Schumpeter. Editions Economie Appliquée; 1951.
Schumpeter J. The theory of economic development. Cambridge: Harvard University Press; 1934.
Smith H. Your product development process demands on going improvement, Research Technology Management, IRI Press, March–April: 1996. p. 37–44.

Product Innovation, Process Innovation

John E. Spillan
School of Business, University of North Carolina At Pembroke, Pembroke, NC, USA

Synonyms

Addition; Alteration; Departure; Modification; Newness; Variation

Definition

General innovation – It is a process that takes an idea or invention and converts it into a product or service that the general public purchase or possess. Innovation(s) are replicable, have economic costs, and satisfy a need. As related to business, innovation is the application of an idea, which reduces the gap between needs of customer and the performance of the company.

(Source: Business dictionary.com http://www.businessdictionary.com/definition/innovation.html).

Specific Definition of Innovative Organization – It relates to new approaches to work and how work is organized, how workflows operate to enhance customers and employee performance, employee retention, and increase in employee knowledge (Kustoff 2008). Organizational innovation requires a culture that supports new ideas, processes, and new ways of doing business. Organizational innovation values knowledge acquisition and learning. As such, continuous learning is necessary for organizational innovation to succeed. Organizational knowledge should focus on change, better processes, better business outcomes, higher customer satisfaction, and increased sales revenue (Kustoff 2008).

Organizational Innovation

As goes innovation so goes a company's competitiveness, sustainability, and a society's economic growth. Growth and sustainability are dependent on continuous innovation. Change and globalization have forced companies to innovate, change, or go out of business. While some believe this state of affairs is disastrous for a company, for people, and for the survival of society as a whole, it is also thought that this process of change and innovation catalyzed by globalization is crucial to our long-term well-being and sustainability. As difficult economic times continue to challenge every manager in every part of the world, innovation becomes the one element of hope for the future sustainability of economic development. Unfortunately, many executives indicate that they have not had the extra cash to invest in business innovation and development. Additionally, the pace of change and globalization has been so fast and intense that executives have not had time to really think

through how innovation would allow them to compete more efficiently and effectively. So businesses are in a squeeze. They must innovate, but it is necessary to have the correct financial situation and competitive situation to innovate properly. So what direction do companies pursue? Well, Joseph Schumpeter would tell them to continue thinking, continue to find ways to innovate because in the long run, the concept of "creative destruction" will eventually take care of their business and their competitiveness. Everything will change and new products and processes will emerge whether one company likes it or not. Creative destruction is the driving force for innovation and it is and will continue to affect all people and all organizations whether they like it or not (Reisman 2004; Diamond 2007; Beaugrand 2004).

Industry context, strategy preferences, and technological capacities many times determine the innovative direction of an organization. In some cases, organizational structures can hinder the innovative process by relying on history, strategy, and operational design (Bishop, 2008). Since it is almost impossible to achieve any level of innovation without the proper organization, it is imperative that managers find ways of constructing organizational structures that bypass these obstacles in order to promote innovation of products and processes. Using innovative resources to produce these products and services is absolutely essential (Lam 2004). This means that to achieve organizational innovation among employees and structures, it is essential that there be a culture that promotes learning and knowledge creation (Singh 2011).

So, for organizations to remain competitive, they must think about organizational innovation. This means that organizations need to consider not just innovating new products and services but also about organizational innovation. Organizational innovation refers to creating business models, management techniques, strategies, and organizational structures that will form the foundation for meeting these competitive challenges of the time. Without organizational innovation, as stated in the above definition, product and service innovation cannot evolve or take place. At the core of business innovation are three organizational constructs:

First, *business model innovation* – this is required in order to focus on different markets for selling goods and services. It may move from a low cost producing company to a value-added company. Thus, it will change the dynamics of the production supply chain and sales management (American Management Association 2006).

Second, *business structure innovation* – to meet strategic goal(s) or focus on new innovations, companies need to change structure(s) to meet these needs. Such innovation can be achieved through merger, acquisition, reorganization, or developing different structures that did not exist in the past (American Management Association 2006). This is an innovative approach where entrepreneurs thrive by exploiting new opportunities.

Finally, *business process innovation* – this is a very popular and common practice among business entities. As new demands occur, new ways of developing and producing products can and do emerge. It focuses on how to produce the product and service versus what is produced or delivered in services. Many times the company can increase productivity and quality through business process innovation (American Management Association 2006).

With this in mind, organizational innovation is a concept that managers and executives have to deal with every day in order to meet the global business competitive demands. So, all organizations, to be successful, must learn how to be a versatile, innovative company that is able to sustain its competitiveness. By developing new processes, creating an innovative culture, and recognizing and rewarding employees who are innovative, managers can achieve a constant and continuous creative system that removes many of the obstacles inhibiting innovation (Singh 2011). As David Neeleman, founder and CEO of Jet Blue, has stated: "Innovation is trying to figure out a way to do something better than its ever been done before" (Singh 2011, p.714).

A central tenet of organizational innovation rests upon the notion of organizational learning. That is the belief that no organization can achieve any innovation of any form unless it promotes organizational learning among its employees. The learning that occurs in the organization offers new knowledge that can be used to develop new business models, new organizational processes, and new business structures. The knowledge sharing provides the key to creating and catalyzing the development of new ideas that lead to different types of innovation (Singh 2011). As the interface of the organizational structure, organizational culture, and organizational learning take place, it can be seen that the development of more elaborate organizational innovation leads to more competitive products and services offered to the global markets (Singh 2011).

Within the context of all innovation, four approaches exist that catalyze any thinking and acting managers or scientists have about moving forward in this area. Innovators must decide whether they will be involved with radical or incremental innovation and whether they will approach the innovative process from a linear or a nonlinear perspective. The two most popular types of innovation can be described as follows:

(a) Radical product, service, or process innovation consists of extraordinary breakthroughs that produce a new or fundamentally altered product, process, or service. Organizations or businesses that achieve success with radical innovation can increase their profits, their prestige, and growth of their organization(s). Specific examples include online shopping, iPad, and cell phones.
(b) Contrarily, incremental innovation improves the existing products, service, or process in such a way that the value of the product, service, or process is significantly enhanced for a period of time. Examples of this include quality management or TQM activities, Six Sigma (Center for Business Innovation 2012).

From another perspective, there are two ways to proceed in initiating and pursuing innovative activity. One way is the traditional linear method of innovation. According to this method, innovation begins with basic research that continues on by adding applied research and development to the results of the first step and then concludes with production and diffusion of the innovative outcomes (Godin 2005). The other way is the nonlinear approach, which means that innovators can take different paths in the innovative process. Generally, this method deviates from the lock-step linear approach. The innovators can pursue different iterations, testing, observations, discovery, and retest. Serendipity is a common element of this approach with a moment of eureka being fantastic for the innovator. The nonlinear path does not require a lock-step method to reach the ultimate conclusion of the process (Creativityland 2011).

The approach taken in the innovative process depends on the philosophy or orientation of the people involved. Moreover, the organization sponsoring the innovation may dictate which method should be used. Either way, the final goal is to produce a better product, a better service, or a better process.

In the final analysis, to innovate is a critical business decision. A company's innovation potential resides in the human resources (talent) it recruits, the organizational culture it creates, and the desire to remain competitive. As such, organizations need to have a clear understanding of what their innovative ambitions really are and what innovation goals they want to accomplish. They also need the funding to pursue its ambitions and a pipeline management approach where not only products are services continuously thought about but acted upon (Nagji and Tuff 2012). Some companies will fail, some will succeed but not having a belief in a desire for or an organizational structure to accommodate innovation will be problematic to any organization, which desires future sustainability. Joseph Schumpeter's "creative destruction" concept is like time and tide; it will wait for no one. Either a company innovates or its existence is in jeopardy and their future will not exist.

Implementation

Thinking about innovation is a relatively simple activity when compared to the execution of the decisions to make innovation happen. The hard work relates to implementing the organizational mechanisms both structurally and culturally that will get results. To effectively employ the innovation process or any innovation project, managers must focus on several important elements:

(a) *Attention to policies and practices* that exist or need to exist companywide to insure that proper training transpires, technology is available, and mechanisms are in place for professionals and staff to access the necessary resources to achieve the innovation goals. If there are too many obstacles in terms of rules and procedures, innovation will be difficult to achieve.
(b) *Attention to the importance* of the innovation and its implementation. If there is an attitude that it is just another ole project with limited importance, then proper implementation will be stifled.
(c) *Participation by managers* – in the implementation process is critical. For managers to stand back and just watch the process will not be appropriate or effective. Managers must take an active role in the innovation process and work associated with implementation of innovation.
(d) *Attention to the financial resources*. Without proper allocation of resources, nothing can be completed and no innovation can really take place. The correct amount of financial resources is also an important consideration in this process.
(e) *Having an organization that is oriented to learning* is absolutely critical. Employees who are enthusiastic about the innovation project and excited about learning will go a long way in helping the implementation process.
(f) *Finally, having patience* – this is one element that seems to be fleeting in many organization's projects. Good things take time to emerge and develop. While time is always of the essence in the innovation business, patience is a critical factor in making sure the innovation project is implemented efficiently and effectively (Klein and Knight 2005).

Conclusions and Future Direction

The way an organization innovates depends on how it is structured. Some are formed to accept incremental change while others are structured to move forward with disruptive change. Being flexible and dynamic in its approaches to innovation is the hallmark of a successful organization. Innovative organizations have to have flexible workflows, adaptable administration, and a dynamic culture. The organization needs to develop different approaches to meet the needs of the context within which it operates (Junarsin 2009). All managers in the contemporary business environment must understand that the pathway to organizational growth and development resides in being innovative. Learning how to manage innovation is critical to a company's success in just about any environment. Mastering this task will pay big dividends in both returns on investment and future competiveness of the organization (Nagji and Tuff 2012). The critical focus of managers should be on making sure that time is spent on efficiently and effectively developing the organization's internal environment and innovative capacities of the entire firm. This investment has large return on investment (ROI) in the future. Being innovative is a growing imperative so now, not tomorrow, is the time for action focused making sure the organization is innovative.

What does the future hold regarding innovation and organizations? Understanding and the preconditions for any innovation to take place is an organization that accepts it as an imperative activity and designs the structure that allows innovation to happen. The following outlines areas of management that will have to be considered for organizational innovation to occur:

(a) New business models that create and capture value within the value chain.

(b) Inexpensive innovation needs to occur where managers have to look for venues for developing innovation in low-income markets that can be transferred to more developed markets (Eagar et al. 2011).
(c) Increasing the speed of innovation in order to reduce the time to market phenomena (Eagar et al. 2011).
(d) Developing appropriate leadership styles that recognize and provide the capabilities to move innovative resources to the right pathways in order to meet complex global market demands.
(e) Development of interorganizational relationships that will create networks for joint ventures that focus on innovative product and service development (Annual Review of Sociology 1999).

Innovation is a timeless exercise, but without it, all organizations lose. There is no time better than the present to begin developing resources and management infrastructures designed to create organizations that are capable of promoting continuous and sustainable innovation(s).

Cross-References

- ▶ Art of Innovation: A Model for Organizational Creativity
- ▶ Business Model
- ▶ Convergent Versus Divergent Thinking
- ▶ Corporate Creativity
- ▶ Corporate Entrepreneurship
- ▶ Creative Collaboration
- ▶ Creative Management
- ▶ Creative Thinking Training
- ▶ Creativity Across Cultures
- ▶ Creativity and Age
- ▶ Creativity and Systems Thinking
- ▶ Digital Economy and Business Creation
- ▶ Entrepreneurial Opportunity
- ▶ Entrepreneurial Organizations
- ▶ Entrepreneur's "Resource Potential," Innovation and Networks
- ▶ Entrepreneurship and Business Growth
- ▶ Entrepreneurship Education
- ▶ Entrepreneurship in Developing Countries
- ▶ Entrepreneurship Policies
- ▶ Imagination
- ▶ Innovation Opportunities and Business Start-Up
- ▶ Innovation Policies (vis-à-vis Practice and Theory)
- ▶ Innovations of Direct Democracy
- ▶ Innovative Milieu as a Driving Force of Innovative Entrepreneurship
- ▶ Innovative Milieux and Entrepreneurship (Volume Entrepreneurship)
- ▶ Interdisciplinarity and Innovation
- ▶ Joseph A. Schumpeter and Innovation
- ▶ Method for Creating Wisdom from Knowledge
- ▶ Open Innovation and Entrepreneurship
- ▶ Organizational Slack and Innovation
- ▶ Political Leadership and Innovation
- ▶ Schumpeterian Entrepreneur
- ▶ Small Businesses and Sustainable Development
- ▶ Strategic Thinking and Creative Invention
- ▶ University Research and Innovation

References

A. Lam Organizational innovation, BRESE, School of Business and Management Brunel University E-mail: alice.lam@brunel.ac.uk, working paper, No. 1; 2004.

A.M. Diamond Schumpeterian labor economics: The Labor Pains (and Labor Gains) from Creative Destruction Department of Economics University of Nebraska at Omaha Omaha, NE 68182–0048 http://cba.unomaha.edu/faculty/adiamond/web/diahompg.htm. 2007. p. 1–69.

American Management Association. The quest for innovation, a global study of innovation management; 2006–2016. pp. 1–86.

Annual Review of Sociology. Organizational innovation and organizational change.Vol. 25.J. T. Hage Center for Innovation. Palo Alto, California: University of Maryland; 1999. p. 597–622.

Beaugrand P. And Schumpeter said, "This Is How Thou Shalt Grow": The further quest for economic growth in poor countries-IMF Working Paper; 2004. p. 1–22.

Bishop K., Creativity Myths, http://allforcreativity.blogspot.com/2008/06/creativity-myths-by-kal-bishop.html, accessed 10 Sep 2012.

Business dictionary.com http://www.businessdictionary.com/definition/innovation.html, accessed 10 Sep 2012.

Center for Business Innovation, Innovation Defined. http://www.conferenceboard.ca/cbi/innovation.aspx (2012). Accessed, 31 Oct 2012.

Creativityland. http://www.creativityland.ca/2011/non-linear-innovation-map-for-those-who-like-discovery/. 2011. Accessed on 31 Oct 2012.
Godin B. The linear model of innovation: the historical construction of an analytical framework, project on the history and sociology of S&T statistics, Working Paper No. 30; 2005. p. 1–36.
Junarsin E. Managing discontinuous innovation. Int Manage Rev. 2009;5(1):10–8.
Klein KJ, Knight AP. Innovation implementation. Curr Dir Psychol Sci. 2005;14(5):243–6.
Kustoff R. "What is Organizational Innovation?" http://www.selfgrowth.com/articles/What_is_Organizational_Innovation.html. 2008. Accessed 10 Sep 2012.
Nagji B, Tuff G. Managing your innovation portfolio. Harv Bus Rev. 2012;90(5):66–74.
Reisman D. Schumpeter's market enterprise and evolution. Edward Elgar Publishing Limited Cheltenham, UK • Northampton MA, US; 2004. 283 p.
Rick Frederik van Oene E, Boulton C, Roos D and Dekeyser C. The future of innovation management: the next 10 years, Prism. 2011. p. 1–37.
Singh SK. Organizational innovation as competitive advantage during global recession. Indian J Ind Relat. 2011;46(4):714–25.
Van de Ven A, Polley D, Garud S, Venkataraman S. The innovation journey. New York: Oxford University Press; 1999. p. 440.

Productive Local System

► Innovative Milieux and Entrepreneurship (Volume Entrepreneurship)

Productive Thinking

► Creative Mind: Myths and Facts

Productivity

► Four Ps of Creativity and Recent Updates

Productivity and Age

► Creativity and Age

Productivity Curve

► Creativity and Age

Project Management

► Method for Creating Wisdom from Knowledge

Promoting Student Creativity and Inventiveness in Science and Engineering

Robert L. DeHaan
Division of Educational Studies, Emory University, Atlanta, GA, USA

Synonyms

Creative problem solving; Education; Innovation; Teaching creativity

Introduction

In his 2011 State of the Union Address, President Obama captured the essence of recent national blue ribbon panels and the conclusions of many economists: "We need to out-innovate, out-educate, and out-build the rest of the world" he said. But to create a workforce with enhanced critical and creative thinking skills, we need to train experts in science and engineering who can find innovative solutions to problems. Scientists and engineers in the laboratory or field frequently encounter ill-structured problems that can have many solutions and multiple solution paths. To approach such problems, "higher order" mental operations are crucial. These include analysis, synthesis, and abstraction but in addition, creative thinking, which

according to Bloom's taxonomy of learning skills is the most complex and abstract of the higher order cognitive skills (Krathwohl 2002). It is creative thinking that allows restructuring of problem parameters and often produces solutions through unexpected insights (DeHaan 2009, 2011).

It is unfortunate that, in the science or engineering classroom, we often teach as if creativity is not important and as if our fields deal only with well-structured problems with known answers and a single way to find the "correct" solution. Not only is no attention paid to creativity, but – with some exceptions such as Eric Mazur's "Peer Instruction," Jo Handelsman's "Scientific Teaching," or Wendy Newstetter's "Problem-driven Learning Labs" – there is little teaching of any of the higher order cognitive skills in most classrooms. For example, Diane Ebert-May and her colleagues found in a national sample of 77 life science courses taught by 50 different instructors that fewer than 1 % of the items on tests and quizzes were judged to require students to use any of these higher level skills. Could this be one reason that Mark Cracolice at University of Montana and his colleagues report that only about one fourth of US college students have the reasoning skills necessary to solve conceptual problems?

The primary question to be addressed here is how undergraduate students can be taught to enhance their higher order thinking skills and especially how to improve the most abstract and complex of these, that is, to think more creatively. There exists an extensive literature promoting instructional strategies to help students be more creative (For reference citations see DeHaan (2009, 2011). But creativity is a complex construct with many components and therefore not easy to define or assess, especially in the context of science. Nonetheless, evidence reviewed by Michael Mumford and colleagues (Scott et al. 2004) demonstrates that the mental operations required for creativity can be taught and that the instructional strategies that work best are relatively simple modifications of those most effective for teaching abstraction and problem solving.

What Is Creativity?

Theoretical Frameworks that Underlie Creativity

Inventiveness or creativity is often seen as a special talent associated with a Mozart, Michelangelo, or Einstein. This is what Kaufman and Beghetto (2008) call big-C creativity, the ability of individuals to generate new ideas that alter an entire intellectual domain. Howard Gardner defined such a creative person as one who "regularly solves problems, fashions products, or defines new questions in a domain in a way that is initially considered novel but that ultimately comes to be accepted in a particular cultural setting" (Gardner 1993, p. 35). Creativity has been defined within two different theoretical frameworks. In one, a novel idea or solution to a problem occurs in the mind of a single individual as a sudden, seemingly unanticipated creative insight or an "aha" experience. In the other, creativity is a social phenomenon that occurs during interactions among knowledgeable individuals. Kevin Dunbar at McGill University has performed ethnographic analysis of interactions of exceptionally productive scientists during their weekly laboratory meetings. These studies reveal that new hypotheses or models are most often generated through discussions among knowledgeable peers. Dunbar reports that when faced with a series of unexpected results, scientists suggest alternative hypotheses or models to test during their lab discussions through "distributed reasoning." This is most effective when the lab group has scientists from diverse backgrounds that have worked with different organisms and a range of different techniques.

But there is another kind of creativity termed mini-C creativity. Mini-C creativity is widespread among all populations and is represented by the "aha" moment when a student first sees two previously disparate concepts or facts in a new relationship, or a worker suddenly has the insight to visualize a new, improved way to accomplish a task. These are both examples of a kind of creative insight; what Arthur Koestler, in the mid-1960s, identified as *bisociation*, "perceiving a situation or event in two habitually

incompatible associative contexts." A classic example in science, among numerous personal accounts, is that of Francois Jacob, co-discoverer of the operon. In a recent essay in *Science*, Jacob describes a creative insight that led to the discovery. Referring to the laboratory of Jacob and Monod at one end of a hall in the Institute Pasteur and that of Boris Ephrussi's group at the other, Jacob says: "Much later came a day in 1958 when, my mind wandering on a lazy July evening, I sensed in a flash that there were important analogies between the systems studied at the two ends of our corridor."

More is known about the mental operations required to produce a creative insight or "aha" experience in an individual mind than the distributed reasoning mechanisms that underlie social creativity. Mark Runco reviewed the evidence in 2004 that two kinds of thinking are required to produce an aha experience in an individual: associative (divergent) thinking, in which thoughts are defocused, intuitive, and receptive to a broad range of associations to a given stimulus, and analytical (convergent) thinking, which provides the capacity to analyze, synthesize, and focus. Efforts to systematically define divergent thinking, which was initially thought to be the main creative element, go back to the 1950s when J. P. Guilford and E. P. Torrance recognized that underlying the construct of creativity were other cognitive variables. According to these pioneers of the field, component mental constructs included ideational fluency (i.e., number of ideas); novelty or originality of ideas; flexibility of thinking (or the ability to produce different types of ideas), as well as sensitivity to problems or missing elements in a situation; and knowing how to search for multiple solutions by making guesses or establishing hypotheses.

Paul Thagard and T. C. Stewart of the University of Waterloo recently introduced the idea of "neural convolution" as a mechanism for integrating disparate concepts or facts in a new relationship in an associative insight. They note that such creative insights often follow conceptual reorganization or a new, nonobvious restructuring of a problem situation. Neuroscience experiments employing magnetic resonance imaging show that different regions of the brain are activated during associative thinking than during analytical problem solving. This is shown when subjects are given remote association problems to solve by associative thinking while lying in a functional magnetic resonance imaging scanner (e.g., find a word that forms a compound word or phrase with each of the following three words: sauce, crab, pine; solution: apple). In this circumstance, brain regions such as the right superior temporal gyrus are more strongly activated than in similar subjects who are given problems to solve by analytical reasoning (Subramaniam et al. 2009). According to Pamela Ansburg and Katherine Hill of Metropolitan State College in Denver, Colorado, associative thinking increases the probability of accessing ideas that are weakly associated with a stimulus, whereas analytical thinking increases the probability that only strongly associated ideas will be accessed from memory.

M. H. Kim and colleagues at Sungkyunkwan University in Korea published a 2007 review of cognitive studies of architects and industrial designers. Their study summarizes the evidence that experts in these fields use strategies for prolonging associative thinking as a means to increase the creativity of design solutions. When design experts encounter an ill-structured problem, they decompose and rearrange components in different contexts, striving to increase the range of associations they apply. Associative thinking is seen as an essential component of creative insight, underlying the argument that science and engineering students, no less than design students, need assistance in enhancing and prolonging associative thinking when dealing with ill-structured scientific problems.

There are numerous strategies meant to achieve this goal. One might be a modification of brainstorming, a technique invented by the advertising executive Alex F. Osborn, that has been shown in modified form to be hugely successful in stimulating inventiveness. In a convincing 2008 *New Yorker* essay, Malcolm Gladwell describes such work by Nathan Myhrvold, the creator of Microsoft's Research Division. Myhrvold has routinely gathered

groups of engineers and scientists around a table for daylong sessions to brainstorm about a prearranged topic, say self-assembly or medical imaging. In the previous weeks, participants will have reviewed the relevant scientific literature and recent patent filings in order to be abreast of the latest information on the topic in their area of expertise. The meetings begin as simple conversations, with few ground rules, but at the end, the group will have produced many patentable ideas. Does the method work? Since it was founded in 2000, Myrhvold's firm, Intellectual Ventures, has filed hundreds of patent applications in more than 30 technology areas, applying the "invention session" strategy. Currently, the company ranks among the top 50 worldwide in number of patent applications filed annually.

The main point from all of these works is that creativity is not a mysterious hard-to-measure property or act. While the relationship between creativity in social groups and individuals remains to be explicated, there is ample evidence that a creative insight requires both divergent and convergent thinking and that it can be explained by reference to other well-understood mental skills such as pattern recognition, model building, ideational fluency, analogical thinking, and exploration and testing of alternatives.

Relationship Between Creativity and Expertise

Creative abilities increase in children up to the age of about 8 years and then steadily decrease with further schooling. Most youngsters become increasingly sensitive to the opinions of their peers and adults after age eight, care more about "fitting in," and become conscious of using objects for their intended use rather than for more whimsical purposes. The result is a decline of creativity that usually continues through college. This situation raises a number of interesting questions:

- Are expertise and creativity mutually exclusive?
- Does the very education that gives a prospective scientist or engineer the expertise required to solve difficult problems decrease the likelihood that he or she will be able to invent creative solutions to those problems?
- Are there instructional strategies for teaching complex, content-laden subjects such as science and mathematics that can enhance inventiveness and creativity instead of dampening these abilities?

An extensive literature suggests answers to those questions. It is clear that experts can be creative. Although traditional teaching methods that rely heavily on lectures and rote memorization may dampen creativity, instructional methods that enhance inventive problem solving have been tested successfully. Teaching students to be innovative demands instruction that promotes creativity but does more than that. A large body of research on the differences between novice and expert cognition indicates that creative thinking arises from a certain level of expertise and fluency within a knowledge domain. Ill-structured problems that arise in the real world can be solved best by individuals who know enough about a field to grasp meaningful patterns of information, who can readily retrieve relevant knowledge from memory, and who can apply such knowledge effectively to novel problems. These individuals exhibit what is referred to as *adaptive expertise*. Adaptive experts are able to learn through problem solving as opposed to simply applying knowledge and familiar heuristics to problems. Instead of applying already mastered procedures, adaptive experts are able to draw on their knowledge to build new models and invent new strategies for solving unique or novel problems within a knowledge domain (Nersessian 2010). They are also able, ideally, to transfer conceptual frameworks and schemata from one domain to another. Such flexible, innovative application of knowledge is what results in inventive or creative solutions.

What Is Known About How to Teach Creativity

Promoting Creativity in the Science and Engineering Classroom

Following the Myrhvold model, imagine a classroom in which the instructor takes the role of facilitator in a monthly "invention session."

For this meeting, the topic might be biofuels from algae or nanoparticles as semiconductors. Members of each team of four to five students will have primed themselves on the topic by reading selected articles from accessible sources such as *Science*, *Nature*, and *Scientific American* and searching the worldwide web, triangulating for up-to-date, accurate background information. Each team knows that their first goal is to define a set of problems or limitations to overcome within the topic and to begin to think of possible solutions. The instructor might spark the discussion by asking one of the teams to describe a problem within this topic in need of solution. Although a classroom invention session may seem fanciful as a means of teaching students to think about science as something other than a body of facts and terms to memorize, engaging learners in the excitement of problem solving, helping them discover the value of evidence-based reasoning and critical thinking skills, and teaching them to become innovative as problem solvers have long been the goals of science and engineering education reformers (Handelsman et al. 2007; Felder and Brent 2009). But the means to achieve these goals, especially methods to promote creative thinking or scientific problem solving, have not become widely known or used.

An important part of solving the problem of how to teach creativity is devising conditions to foster such a mental state. On the website of the Center for Development and Learning, Robert Sternberg and Wendy M. Williams offer 24 "tips" for teachers wishing to promote creativity in their students (www.cdl.org/resource-library/articles/teaching_creativity.php). Among them are the following admonitions:

- Model creativity – students develop creativity when teachers model creative thinking and inventiveness.
- Build self-efficacy – all students have the capacity to create and to experience the joy of having new ideas, but they must be helped to believe in their own capacity to be creative.
- Sprinkle question throughout every lecture – make questioning a part of the daily classroom exchange. It is more important for students to learn what questions to ask and how to ask them than to learn the answers.
- Encourage idea generation – students need to generate their own ideas and solutions in an environment free of criticism.
- Cross-fertilize ideas – avoid teaching in subject-area boxes, a math box, a science box, etc.; students' creative ideas and insights often result from learning to integrate material across subject areas.
- Imagine other viewpoints – students broaden their perspectives by learning to reflect upon ideas and concepts from different points of view.

Strategies like these have been grouped under the term "scientific teaching," a highly successful pedagogical approach designed to reduce rote memorization and to promote active learning on the part of the student (Handelsman et al. 2007; Ruiz-Primo et al. 2011). But even in those courses where active learning instruction has been employed, the emphasis has generally been limited to analysis, synthesis, and critical reasoning, the higher order cognitive skills that are less abstract than creative thinking on Bloom's scale (Krathwohl 2002). We expect science and engineering students to solve problems, but we rarely ask them to search for novel problem solutions through the extended exercise of associative thought. Students need to be reminded that there may be other ways to view a problem than the way it is presented; to list the problem features and then try to rearrange or restructure them, or look at them from different angles; and to generate many ideas about possible solutions before beginning to evaluate which of them may be best.

Do these strategies work to enhance creative thinking? A meta-analysis of 70 creativity training studies revealed that the number and diversity of associations could be increased by teaching students techniques to increase associative thinking (Scott et al. 2004). Below are some specific strategies from a prior publication (DeHaan 2011) that are thought to increase students' access to creative insights. With practice, each strategy should take no more than 4 min when inserted into a standard 50-min lecture.

- *Think-Pair-Share-Create*: This variation of the classic think-pair-share strategy is

especially useful for fostering associative thinking in ill-structured problem solving. Part way into a lecture, the instructor poses an open-ended question or problem, gives students 1 min to think individually about an answer, asks them to pair up with a neighbor to briefly discuss and reconcile their responses, and finally, reminds students to list the features of the problem, try to restructure or reframe their ideas, and to think of as many solutions as they can. The instructor then calls on several individuals or pairs (not volunteers) to share their responses. This exercise can also serve as preparation for a design-based project to be carried out later in a laboratory setting.

- *Peer Instruction*: As modified from the work of Eric Mazur, the instructor poses a question and asks students first to find as many answers as possible on their own, again by feature listing and reframing. They then attempt to justify their best answer to one or more of their peers, and finally they record a consensus response.
- *Think-Aloud-Pair-Problem Solving*: Retrieving information from memory (self-testing) is known to be a better learning strategy for students than restudying the same information. In this maneuver, modified to promote associative thinking, the instructor poses a problem from previous readings for the class and has the students form pairs with one member serving as the *explainer* and the other as the *questioner*. The explainers are given 2 min to recombine from memory components of the original problem into a new configuration with a different solution, while the questioner asks for clarifications or gives hints when necessary. The instructor repeats this with a different problem at another point in the lecture with the students in reversed roles. The process is stopped after the allotted time, and several explainers are asked to report their new solutions.

Conclusion and Future Directions

If this entry achieves its goal, it will stimulate new research on both the role associative thinking plays in science and engineering, as well as in creativity in these fields. Studies are needed especially to test the hypothesis that teaching students to increase their associative thinking will increase the originality and novelty of the solutions they pose to ill-structured problems. A small but growing number of science and engineering instructors are already engaged in active learning pedagogies aimed at improving students' scientific concept formation (Nersessian 2010) and reasoning skills (Felder and Brent 2009; Ruiz-Primo et al. 2011). They and their more reluctant colleagues deserve encouragement to try some of the strategies described above. If the result is that more of our students learn to think like creative scientists and engineers, it will be well worth the effort.

Cross-References

- ▶ Brainstorming and Invention
- ▶ Cognition of Creativity
- ▶ Convergent Versus Divergent Thinking
- ▶ Creative Collaboration
- ▶ Creative Pedagogy
- ▶ Creative Thinking Training
- ▶ Creativity Definitions, Approaches
- ▶ Creativity from Design and Innovation Perspectives
- ▶ Creativity Tests
- ▶ Creativity Training in Design Education
- ▶ Creativity, Experiential Theories
- ▶ Divergent Thinking
- ▶ Fostering Creativity Through Science Education
- ▶ Higher Education and Innovation
- ▶ Psychology of Creativity
- ▶ Scientific Creativity as Combinatorial Process

References

DeHaan RL. Teaching creativity and inventive problem solving in science. CBE Life Sci Educ. 2009;8(3):172–81 (http://www.lifescied.org/cgi/reprint/8/3/172).

DeHaan RL. Teaching creative science thinking. Science. 2011;234:1499–500.

Felder RM, Brent R. Active learning: an introduction. ASQ High Educ Brief. 2009;2(4):1–5.
Gardner H. Creating minds: an anatomy of creativity seen through the lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi. New York: Harper Collins; 1993.
Handelsman J, Miller S, Pfund C. Scientific teaching. New York: Freeman; 2007.
Kaufman JC, Beghetto RA. Exploring mini-C: creativity across cultures. In: DeHaan RL, Narayan KMV, editors. Education for innovation: implications for India, China and America. Rotterdam: Sense; 2008. p. 165–80.
Krathwohl DR. A revision of Bloom's taxonomy: an overview. Theory Pract. 2002;41(4):212–8.
Nersessian NJ. Creating scientific concepts. Cambridge, MA: Bradford Books; 2010.
Ruiz-Primo MA, Briggs D, Iverson H, Talbot R, Shepard LA. Impact of undergraduate science course innovations on learning. Science. 2011;331:1269–70 (11 Mar 2011).
Scott G, Leritz LE, Mumford MD. The effectiveness of creativity training: a quantitative review. Creativity Res J. 2004;16:361–88.
Subramaniam K, Kounios J, Parrish TB, Jung-Beeman M. A brain mechanism for facilitation of insight by positive affect. J Cogn Neurosci. 2009;21(3):415–32.

Prospection

► Imagination

Protest Movements

► Antitechnology Movements: Technological Versus Social Innovation

Proximity

► Microfirms

Proximity Relations

► Innovation Systems and Entrepreneurship

Proximity Relationships and Entrepreneurship

André Torre
AgroParistech, UMR SAD-APT, Paris, France

Introduction

Proximity Relations at the Heart of Firms' Strategies

In the present days of clusters, localized production systems, districts, or technopoles, it is not surprising that the question of proximities is raised with force in the analysis of firms' strategies and the relations they form with their partners, competitors, and more generally with the economic and social environments in which they conduct their everyday activities. Moreover, this aspect has not escaped the makers of economic, industrial, or innovation policies, who unceasingly plead in favor of structures in which economic activities are concentrated, whether they be competitive clusters in France, industrial districts in Italy, technopoles and science parks in Britain and Japan, or the different types of clusters that exist all over the world (OECD 2001).

The studies devoted to the analysis of proximity relations are based on research situated at the

André Torre is research director at INRA (National Institute of Agronomical Researches) and AgroParisTech in Paris. He is past President of the French-speaking section of ERSA, director of the PSDR (For and About Regional development) research programs, and head of the "Proximity team" in Paris. André Torre has published more than 100 articles and 11 books, mostly on issues related to space and coordination between people or groups of people, on the topics of proximity, innovation, and regional development. Its research was for a long time at the crossroads of spatial and industrial economics; it has in recent years become more multidisciplinary and focused increasingly on questions related to land use planning and sustainable development processes. It currently focuses on the analysis of proximity relations and on their importance in processes of coordination between people, and centers on two main areas: local interactions between innovative firms and, more particularly, the role played by geographical proximity in the transfer of knowledge, land use, and neighborhood conflicts.

intersection of industrial and spatial economics (Torre and Gilly 1999), which found, in the 1990s, that one could not study enterprises and their strategies without taking into account the spatial and geographic dimensions of their activities (see entry "► Territory and Entrepreneurship"). This has resulted in a large number of studies – some of which are presented below – all of which refuse to dissociate the economic from the geographical aspects and all of which take into account various dimensions of proximity relations. The relational or organizational dimension is combined to the spatial dimension of proximity – which is the most obvious. One may feel close to people located great distances away, and this is true of work and personal relations.

The analysis of proximity relations has subsequently been extended to many other fields, such as that of environmental questions and of urban or transport policies, for example. But the industrial and productive dominance has remained strong, and there has been a marked interest in issues related to innovation and knowledge-based economy. Thus, a large part of the research on the different types of proximity is devoted to two topics related, primarily, to questions of entrepreneurship (see entry "► Entrepreneur"), with the idea that a firm must take into account, in its strategies, the two categories of proximity relations. Thus, some studies focus on analyzing interfirm relationships, approached from the perspective of local or long-distance collaboration and of firms' ties with their local environment. Many other research studies have examined innovation questions related to innovative firms and their productive and scientific environments or to firms that wish to acquire or transfer technologies or knowledge (see entry "► Innovation and Entrepreneurship").

Definitions

The following definitions of the proximity-based approach are based on a division according to two main dimensions – spatial and nonspatial – which include more refined and detailed categories (Torre and Rallet 2005).

Geographical Proximity

Geographical proximity is above all about distance. In its simplest definition, it is the number of meters or kilometers that separates two entities. But it is also relative in terms of the morphological characteristics of the spaces in which activities take place, of the availability of transport infrastructure, and of the financial resources of the individuals who use these transport infrastructures.

Geographical proximity is neutral in essence, but it can be activated or mobilized by the actions of economic and social actors, in our case, firms, labs, or institutions. Depending on their strategies or strategic choices or according to their perceptions of their environment, the behaviors and attitudes of these actors vary, and they mobilize geographical proximity differently. More precisely, actors might seek to get closer to or further away from certain people or places, or they might feel satisfied or dissatisfied with the geographical proximity of certain people, places, or technical objects. Geographical proximity can be enhanced in the context of an urban area by the creation of localized innovation clusters (see entry "► Clusters"), for example, or by the development of local networks of producers, exchanging knowledge and information through face-to-face contacts.

Organized Proximity

Organized proximity too is a potential that can be activated or mobilized. It refers to the different ways of being close to other actors, regardless of the degree of geographical proximity between individuals, the qualifier "organized" referring to the arranged nature of human activities (and not to the fact that one may belong to any organization in particular). Organized proximity rests on two main logics, which do not necessarily contradict each other and which are called the *"logic of belonging"* and the *"logic of similarity."*

The logic of belonging refers to the fact that two or several actors belong to the same relationship graph or even to the same social network whether their relation is direct or intermediated. It can depend on the sector they are operating on; in

this case, they share common creative or innovation capital. It can be measured in terms of degrees of connectivity, reflecting more or less high degrees of organized proximity and therefore a more or less great potential of interaction or common action. Cooperation will, a priori, develop more easily between researchers and engineers who belong to the same firm, the same technological consortium, or innovation network (see entry "▶ Network and Entrepreneurship").

The logic of similarity corresponds to a mental adherence to common categories; it manifests itself in small cognitive distances between some individuals. They can be people who are connected to one another through common projects, or share the same cultural, religious (etc.) values or symbols. Social norms and common languages partake of this organized proximity. It can also, however, correspond to a bond that sometimes emerges between individuals without them having had to talk in order to get to know one another. It facilitates the interactions between people who did not know one another before but share similar references. Engineers who belong to the same scientific community will easily cooperate because they share, not only the same language, but also the same system of interpretation of texts, results.

Temporary Geographical Proximity

Temporary geographical proximity (TGP) constitutes one form of geographical proximity that enables actors to temporarily interact face-to-face with one another, whether these actors are individuals or organizations such as firms or laboratories, for example. It corresponds to the possibility of satisfying needs for face-to-face contact between actors by traveling to different locations. This traveling generates opportunities for moments of geographical proximity, which vary in duration, but which are always limited in time. TGP is limited to certain times; this form of geographical proximity should not be mistaken for a permanent co-location of firms or laboratories.

The development of communication technologies and ICT nowadays facilitates long-distance exchange. A large part of the information and knowledge that are necessary for production or innovation activities can be transferred from a distance, through telephone or Internet-mediated exchanges, for example. Consequently, co-location no longer constitutes an absolute necessity. However, times of face-to-face interaction are necessary and beneficial in this context. Face-to-face interaction cannot altogether be eliminated, including in the case of communities of practice, for example (see Torre 2008). As a consequence, ICT cannot be considered as substitutes for face-to-face relations: Both are useful tools to support or enhance the interaction between two or several individuals. Space matters but in a new way: one that consists of temporary face-to-face contact between two or several individuals.

Theoretical Origins and Debates Regarding the Concept

The first research studies on proximity were conducted in the early 1990s and led to the creation of the so-called Proximity Dynamics group in 1991 and later to the publication in 1993 of a special issue of the *Revue d'Economie Régionale et Urbaine,* entitled "Economies of Proximity" (Bellet et al. 1993). In that special issue, which was written entirely by researchers of this movement and which subsequently resulted in the creation of what is now commonly called the "French School of Proximity," were published various articles, all of which presented the concept and approached in different ways questions pertaining to production and innovation processes. All the articles are devoted to production-related questions and place emphasis on the geographical component of these relations. This journal's special issue advocates the integration of the spatial dimension in the analysis of industrial relations and provides a first interpretation of proximity relations. It introduces two types of proximity, called "geographical proximity" and "organizational proximity," respectively; at the intersection of both categories, one finds the so-called territorial proximity: a notion

which deals with the complex interplay between productive relations and spatial relations and their being inextricably linked.

The following publication by the group of a multiauthored book (Rallet and Torre 1995) shows that the authors, most of whom are either industrial economists interested in spatial questions or spatial economists interested in industrial issues, all prove to be passionate about the topic of productive relations, and their development at the level of territories, and have a particular interest in approaches to innovation. Their analysis did not develop out of nothing, nor without any theoretical bases. These authors inherited analyses carried out from a territorial perspective, on questions pertaining to localized production systems, and more particularly of industrial districts and innovative milieus (see entry "▶ Innovative Milieux and Entrepreneurship (Volume Entrepreneurship)"). They are the followers of a relatively heterodox tradition and reject both the idea that the economy is only dependent on commercial relations and that of a separation of the productive dimensions – mostly studied by economists – from the more spatial dimensions, which are generally examined by geographers. Thus, the approach is meant to be multidisciplinary, even though it emerged from economic analyses.

Standard economics has not paid much attention to the questions of proximity and has seldom used the term. Indeed, it generally prefers approaches in terms of distance or location: Space is, at best, treated as data, the effects of which on economic activities and therefore firms must be taken into account. The models are characterized by a tension between interfirm competition – which forces them to go further away in order to obtain selling space for their products – and their search for advantages drawn from location close to clients or to competitors. The benefits of proximity, much praised, are seldom explained and are to a large extent mistaken for the very process of spatial agglomeration, to which proximity can contribute without necessarily being associated to it. Even the New Economic Geography, which is a relatively recent movement, has not shown any interest in the question.

But other studies have attempted to open the "black box" of proximity relations. Whereas the standard approaches consider proximity relations as causative variables, without their content being ever considered, other works have tried to understand proximity relations by attempting to highlight their significance as well as their different contents. This movement has been largely inspired by the highly influential district, milieu, and SPL approaches, which have opened the way to un-self-conscious research on "the local." The authors in this research movement have placed emphasis on the relations between firms and on the networks that develop, mostly at local level. They have highlighted the systematic nature and the importance of these systems' structures and modes of organization. They also showed that industrial districts are not the result of a concentration of firms initially attracted by favorable factors, such as primary resources for instance. Rather, they are built upon an organizational settlement in the territory which makes the "disengagement" from relations to an area or a local system difficult for producers, given the presence of local skills and trained workers.

A second track of research into the origins of the externalities of proximity resides in the approaches that emphasize the horizontal links within localized production areas. The traditional analysis of external economies is challenged here because the frontier of the firm fades in favor of the organization into networks, like that found in the emblematic case of the Silicon Valley (Saxenian 1994). Beyond the characteristics purely linked to the specificity of the technologies in question, three main dimensions are at the origin of the competitiveness of these industrial systems: (a) the existence of local institutions guaranteeing the circulation of a local culture, (b) the specificity of the firm's internal organization, and (c) the presence of a particular industrial structure based on the existence of recurrent contacts between local actors.

The third track of analysis is found in the so-called geography of innovation (Feldman 1994) which emphasizes the process of spatial concentration of innovative activities, be there within regions or smaller geographical areas,

and directly introduces the notion of proximity into the analysis. Innovation is concentrated essentially in a few zones in which one can find not only units of production but also public research laboratories or universities (see entries "► Invention and innovation as creative problem-solving activities" and "► University Research and Innovation"). This empirical evidence reintroduces the idea of the importance of the relations of proximity in the generation of the new technologies. Moreover, the link between this movement and that of the spatial concentration of industrial activities is made: Firms' choice of location can be explained by their need to develop relationships not only with other firms (interfirm relations) but also with science (science-industry relations).

The group has also inherited a great deal from the research conducted on industrial economics, on value chains and industrial groups, or on the microeconomics of imperfect competition and firms' strategies. But it is also largely indebted to evolutionist and institutionalist approaches. The role of institutions is always emphasized, and industrial relations are presented as forces driving the processes of change and of transformation of economies, which mostly rest on innovations and technological changes. Similarly, the research on proximity moves, from the start, beyond methodological individualism by repositioning the individual or the firm within a network of social or economic relations. The firm is never considered as an isolated entity, but it is always regarded as being part of groups of actions, local systems, or long-distance networks.

Applied Studies and Theoretical Advances

On the basis of these principles, a large series of applied studies were conducted, focusing primarily on industrial firms and their relations or on technological interactions, and these applied studies have rested on a proximity-based approach. They have mostly examined the case of France and have focused essentially on productive systems such as the Toulouse, Grenoble, or Marseilles "technopoles" or on organizational structures such as innovation networks or cooperatives for instance. They reveal that the formation of relations between firms located in the same areas is not exclusively related to their geographical proximity. Social ties, interfirm relations, trust, networks of actors, friendships, and successful collaborations all contribute to forming a web locally: a web which matters at least as much as co-location. In light of this network, one clearly understands the factors of what can be called the firms' "ties to their territory." Each tie is fragile and must be nurtured and stands as a veritable resource for firms, which hesitate all the more to move to different locations as the web they have woven with other local actors is strong.

Nevertheless, the development of the research on proximity, which continues to give rise to collective publications that provide provisional assessments of the analysis and of its progress (see, e.g., Torre and Gilly 1999, or Pecqueur and Zimmerman 2004), has quickly led to an in-depth debate on the different forms of proximity. Besides the authors who argue that there are two main types of proximity, called geographical and organized (or organizational) proximity, respectively – as seen above – there is a variant school of thought that considers that the political and institutional dimensions play such a central part that it is necessary to posit the existence of a third category: institutional proximity. The latter is defined as the actors' adherence to a space that is defined by common rules of action, representations, and thought patterns (Kirat and Lung 1999). The authors of this school reckon that the political dimension, the importance of the legal component, of the rules that govern the social and economic relations justify the creation of this category, all the more so as organized proximity is thought to be essentially cognitive in nature. As for the defenders of the first approach, they consider that these dimensions are encapsulated within the logic of similarity.

With the rising popularity of the research on proximity, new, non-French-speaking researchers have, since the 2000s, joined the debate and have contributed new directions and

taken into account new concerns. One of the most remarkable contributions has resulted in an increase in the number of proximity categories, which the founding fathers had preferred to limit for the sake of analytical coherence, but which has exploded in order to take into account the different facets of proximity and reveal their extraordinary malleability as tools of reflection. Five types of proximity are nowadays often described: They are called cognitive proximity (common knowledge bases and competences), organizational proximity (the extent to which relations are shared in an organizational arrangement), social proximity (the embeddedness of the trust relations based on friendship, family ties, and experience), institutional proximity (adherence of the economic actors to common rules, such as structures, laws, political rules, and common values), and geographical proximity (Boschma 2005).

Simultaneously, as a result of the emergence of new societal concerns and of the arrival in the group of sociologists, geographers, and land planning experts, there has been an extension of the topics and themes addressed. This extension has taken several directions consisting, for example, in taking into account issues related to the environment, land planning, transport, urban or rural planning, or of a question of particular interest to us: the importance of new information and communication technologies in the relations between firms located in proximity to or far from one another. It has also sounded the knell of the eulogistic way of looking at proximity. The negative dimensions of the various types of proximity are now highlighted, particularly those of geographical proximity, which appears not only to generate land use conflicts in situations where space is scarce but also to be conducive to problems in terms of relations between innovative firms, for example: Indeed, a classic finding is that geographical proximity facilitates industrial espionage and therefore the unwanted appropriation of knowledge by firms' rivals, and also that production systems that give priority to internal relations at the expense of external relationships may find themselves in negative development trajectories.

Many research studies have been conducted, particularly in European countries, on the basis of the proximity-based approaches, and often by using field data and the econometric tools. They often begin with the analysis of one particular sector – software or aeronautics, for example – with a marked interest in knowledge-intensive industries or technological innovation sectors. They seek to test the importance of the different types of proximity in firms' performance and often confirm that geographical proximity cannot alone ensure high performance, nor does it in itself facilitate the exchange or interactive creation of knowledge. Thus, it is the nonspatial dimensions of proximity that now have the place of honor, and more particularly their role in the creation of networks of economic actors, located either in proximity to or far from one another: Indeed, these networks rest mostly on different dimensions – social, relational, cognitive, etc. – which do, indeed, correspond to the components of the different types of proximity (Boschma and Frenken 2010).

Conclusion and Future Directions

The most recent development of the analysis of proximity relations, dating from the second half of the 2000s (Torre 2008), has been the publication of research studies on the temporary dimensions of proximity and particularly of geographical proximity. They have been based on three findings. The first has to do with the increasing number of fairs, trade shows, and conventions, which bring together, in given places and for very short periods of time, people located varying distances away from one another but who nevertheless are able to communicate through ICT. The second finding is related to the increasing mobility of individuals, mobility which concerns private persons but also engineers or business owners or managers. The third and last finding is linked to the analysis of the relations developed by firms that form clusters in specific fields such as that of biotechnologies, for example: Though they reap financial and real

estate-related advantages from being located in the same areas as other firms that belong to the same sectors of activity, they often prefer to form relationships with outside firms so as to prevent problems related to the leaking or loss of intellectual property between themselves and rival companies.

This has led some researchers to examine the way in which firms located distances away from one another communicate. One knows that they mostly do so through ICT but also through the inevitable implementation of geographic interfaces: Different cases of communication are examined: long-distance communication, fairs, and conferences, as well as temporary "platforms" of project teams, implemented by large manufacturing groups such as EADS or Renault in order to enable the participants of a project to work together in the same place for short periods of time, participants who will subsequently go back "home" and work together from a distance. As has always been shown since the first research studies on proximity were performed, space and geography do matter, but researchers have moved far beyond the exclusive analysis of clusterized firms, even though these new considerations have considerably enriched it.

References

Bellet M, Colletis G, Lung Y. Économie de proximités. Revue d'Economie Régionale et Urbaine. 1993;3:357–606.

Boschma RA. Proximity and innovation. A critical assessment. Regional Studies. 2005;39(1):61–74.

Boschma R, Frenken K. The spatial evolution of innovation networks: a proximity perspective. In: Boschma R, Martin R, editors. The handbook on evolutionary economic geography. Cheltenham: Edward Elgar; 2010. p. 120–35.

Feldman MP. The geography of innovation. Boston: Kluwer Publishers; 1994. p. 155.

Kirat T, Lung Y. Innovation and proximity. Territories as loci of collective learning processes. European Urban and Regional Studies. 1999;6(1):27–38.

OECD. Innovative clusters, drivers of national innovation systems. Paris: OECD; 2001. p. 420.

Pecqueur B, Zimmerman JB, editors. Economie de Proximités. Paris: Hermès, Lavoisier; 1994.

Rallet A, Torre A. (eds.), 1995, Economie Industrielle - Economie Spatiale, Economica, Paris.

Saxenian AL. Regional advantage: culture and competition in Silicon Valley and route 128. Cambridge, MA: Harvard University Press; 1994. p. 226.

Torre A. On the role played by temporary geographical proximity in knowledge transfer. Regional Studies. 2008;42(6):869–89.

Torre A, Gilly JP. On the analytical dimension of proximity dynamics. Regional Studies. 1999;34(2):169–80.

Torre A, Rallet A. Proximity and localization. Regional Studies. 2005;39(1):47–60.

Psychological Aspects of Entrepreneurial Dynamics

Gerhard Krauss
Faculty of Social Sciences, University of Rennes 2, Rennes, France

Synonyms

Entrepreneurial behavior; Entrepreneurial development; Entrepreneurial personality

Introduction: Basic Concepts and Variables

Both terms "entrepreneurial" and "dynamics" address a non-static perspective, emphasizing the ongoing processes and the driving aggregate forces associated with entrepreneurship. The intervening psychological variables concern the human actors involved in these processes.

On the micro- and intermediate levels, the mentioned concepts refer to entrepreneurs and entrepreneurial interactions, that is, their capacity to act as a motor of move (implying undertaking spirit, initiative, capability of recognizing opportunities, creative imagination, ability of transforming emerging ideas into concrete-projects, etc.). Entrepreneurial actors are often starting up and conducting one or several challenging projects and the related tasks.

On the community and organizational levels, the concepts refer to the enterprise as the formal frame, as well as to the community of the

companies contributing together to the collective movement of change. The emergent collective forces generated are the result of the actions of individual entrepreneurs and their companies, which in return influence the entrepreneurial behavior and orientation of individuals and firms.

Entrepreneurial action and the dynamics resulting from it comprise an important psychological component. Its relevance results from the fact that entrepreneurial action is based on interactive activities and that human actors, especially entrepreneurs, cannot be reduced to cold, passionless, emotionless, and rationally calculating actors. On the contrary, it is typical for them to associate their behavior with passions, feelings, emotions, and individual and collective thinking. Human action, in general, and that of entrepreneurs, in particular, is charged with emotions, subjective goals and perceptions. It can be supposed that mental processes, feelings, perceptions, ideas, and ways of thinking and behaving must represent an important aspect of entrepreneurial dynamics.

Psychological variables have a varying influence on entrepreneurship. Many scholars have particularly been interested in the role played by psychology in the early phases of nascent entrepreneurship, where uncertainty is high and the individual entrepreneur is highly involved (eventually assisted by one or more other entrepreneurial persons). Aldrich (1999), in an evolutionary perspective, distinguishes the phases of "conception," "gestation" (nascent entrepreneurs), "infancy" (new firms), and "adolescence" (establishment of the founded firms).

Theoretical Origins and Debates: The Relationship Between Economics and Psychology and its Assimilation by Entrepreneurship Research

The psychology of economic behavior has interested numerous scholars since a long time. An example is the pioneering contribution of Gabriel Tarde in nineteenth-century France who has studied the phenomenon from the point of view of the philosophy of difference (Lazzarato 2002). For Tarde, the concepts of imitation and invention are central which are directly linked to psychological variables (belief and desire). Later on, other famous scholars of the twentieth century known for linking economics and psychology are, for example, James G. March or Herbert Simon. Both were particularly interested in the role that cognitive and psychological variables may play in decision making – an activity which is recognized as central for entrepreneurship.

In the field of entrepreneurship research, there has then emerged a more or less clear and fundamental opposition between two types of schools, which for a long time should mark the development of psychological approaches to entrepreneurship: on the one hand, those who focused on the psychological characteristics of the individual entrepreneur (trait approach), linking entrepreneurship directly to the psychological profile of the entrepreneur, and, on the other, those refuting such an approach, claiming that the entrepreneurial interactive process is central for analysis, independently of any individual characteristics of the entrepreneur.

However, more recently, attempts were made to overcome this opposition and to develop more appropriate and more complex psychology-based explanations by combining the different perspectives. In the following sections, firstly the traditional trait approach perspective will be presented, secondly its critique, and thirdly some of the attempts made to develop more sophisticated and more complex explanation models.

The Trait Approach

The trait approach represents a major psychological perspective applied to entrepreneurship. It has been particularly influent in the 1980s and stimulated a lot of research work during this decade. The starting point is the idea that personal characteristics or "traits" of the people running firms matter and indeed are seen as determinant for the development of these latter. This applies as well as to incumbent as to new firms, but the approach has been used especially for new firms and founders. In this case, in general, attempts

were made to explain the success or failure of a start-up company by the psychological profile of its founder(s).

This perspective has important theoretical implications. It includes a rather strange paradox: Whereas the entrepreneur normally is supposed to be a *dynamic* actor, oriented toward innovation and change (economic, technological, institutional, etc.) – which itself logically would require a dynamic theoretical perspective – the conceptualization of this actor in the trait approach in contrast reflects a rather *static* thinking. According to this view, the entrepreneur is supposed to have a fairly stable personality profile, which is innate: either one is an entrepreneur or not. This is seen as a question of psychological character and personality. The basic idea is that an entrepreneur has certain internal characteristics and dispositions which influence or determine his entrepreneurial behavior.

However, it remains an open empirical question if these personality factors are generally dominant, how they interact with situation and context, and what influence these latter have. In addition, the postulate of the relative stability of traits may be questioned: Can traits evolve and change over time? Are they inborn or acquired through socialization and learning? Does "learning by doing" play a role in the domain of entrepreneurship? Do people develop certain entrepreneurial traits thanks to the experience of founding and running a business?

A lot of research has been done in order to identify "who is an entrepreneur" (Gartner 1988) and to study what distinguishes him from non-entrepreneurs. Among the mostly studied attributes figure "need for achievement," "locus of control," or "risk taking," but this short list is not exhaustive; others and less mentioned are, for example, "values" or "age" (Gartner 1988: 11–12). People with high levels of need for achievement are those privileging challenging, but achievable tasks; people with an internal locus of control are those who think being able to determine their destiny themselves (in opposite to people with an external locus of control who feel to be constrained by their external environment); finally, risk taking is generally seen as a typical attribute, but it is also recognized that entrepreneurs are not foolish; their risk taking is rational and calculated. More examples are included in the table presented by Gartner in his article, among which figure "self-discipline and perseverance," "action orientation," "goal orientation," "autonomy," "aggression," "innovative tendencies," "creativity," "desire for money," "tolerance of uncertainty," "tolerance of ambiguity," and so on, quoting only some of the numerous characteristics attributed to the entrepreneur in the literature (Gartner 1988: 16).

The different traits (separately or in combination) were not only used by scholars to differentiate entrepreneurs from non-entrepreneurs, or from managers, but also to compare different types of entrepreneurs, such as "nascent entrepreneurs," "novice entrepreneurs," "habitual entrepreneurs," "serial entrepreneurs," or "portfolio entrepreneurs" (Chell 2008: 9). Different trait approaches can be distinguished. For example, Chell (2008: 84) presents a typology of no less than seven different ways of using trait theories: (1) single trait approach, focusing on one particular trait which is studied; (2) multiple trait approach, studying a combination of traits; (3) personality structure, identifying a coherent system of traits; (4) cognitive traits, focusing on the cognitive dimension of personal characteristics (beliefs, perceptions, cognitive styles); (5) biologically based traits, linking traits to biological differences between people; (6) abnormal traits (e.g., depression, psychopathy, hypochondria, etc.); and (7) psychodynamic theories, insisting on the importance of childhood experiences and the resulting subconscious, firmly implanted, compulsions and anxieties.

Trait theory finally has evolved further, and an emergent consensus is developing around scholars about the necessity to develop more complex models, among others, by recognizing the interrelationship between trait characteristics and situational or more general environmental conditions. In addition, modern trait research is increasingly concerned by a search of and the research on new traits (Chell 2008: 247), alternatively to the dominant classical ones mentioned above (which were need for

achievement, internal vs. external locus of control, and risk taking). In her book on the entrepreneurial personality, Elisabeth Chell enumerates several newly emerging traits, among others, for example, "opportunity recognition," "proactive personality," "self-efficacy," "social competence," and "intuition" (Chell 2008: 247). The emergence of these new traits in the theoretical debate emphasizes not at least the growing importance given to a cognitive view of entrepreneurial action. Studying entrepreneurial cognition may be seen in this context as a promising research strategy that might allow "to bring the entrepreneur back into entrepreneurship" (Krueger 2003: 105) by suggesting that the cognitive infrastructure of entrepreneurs (the way how entrepreneurs think, memorize, and learn to perceive opportunities) differentiates them from other people.

Major Criticism Addressed Toward Trait Research

Trait research developed particularly well since the late 1970s and became rather popular among scholars especially during the 1980s. However, it never formed a very homogenous theoretical school. The field of entrepreneurial trait research was rather heterogenous and dispersed and, in addition, provoked a very critical and conflictual debate among scholars in the second half of the 1980s. The critique of Gartner (1988, 1989) at the end of the 1980s is very instructive in this regard and summarizes the main critiques of that time. One of the arguments presented concerned the difficulty to define the entrepreneur and to identify clearly the traits that would differentiate him from non-entrepreneurs. While Gartner insisted on the impossibility to develop a generic definition, he criticized trait scholars for defying the doubts and attempting to distinguish entrepreneurs from other people by their personality characteristics. Gartner criticized that many different, and often vague, definitions of the entrepreneur were used, many researchers even not taking the effort at all to define the entrepreneur, and that the heterogeneity of the research samples finished by making it completely impossible to distinguish clearly between entrepreneurs and the rest of the population, or between successful and unsuccessful entrepreneurs. A "psychological profile" of the entrepreneur assembled from the different studies, according to Gartner, "would portray someone larger than life, full of contradictions, and, conversely, someone so full of traits that (s)he would have to be a sort of generic 'Everyman'" (Gartner 1988: 21).

Gartner's final conclusion was quite radical: He stated that the trait view is inadequate for understanding the entrepreneurial phenomenon. Instead of focusing on the personal and psychological characteristics of the entrepreneur, research should better concentrate on the study of the concrete behavior and activities of entrepreneurs, that is, adopt a process-oriented view (behavioral approach). Gartner illustrated his argument by a comparison with sports. For example, in the case of baseball, "a baseball player is not something one is, it is something one does" (Gartner 1988: 22). What would be important is the baseball *game* and **not** the *player*. In sum, entrepreneurship research should focus on what may be seen as central, which according to Gartner's interpretation is synonymous with the start-up process, the efforts made by individuals to create organizations, and their outcomes (Gartner et al. 2004).

The general orientation of such criticism at a first glance could appear as a turnabout in the theoretical debate at that time. However, like the classical trait approach, it was based in reality on an artificial isolation of one particular element of entrepreneurship, impeding a full understanding of the phenomenon. In the end, it led to a rather unfruitful opposition between two contrasting perspectives: a trait perspective on the one hand which was strongly criticized and an exclusively behavioral (or process) perspective on the other. While the former put the entrepreneur in the center of its model, the latter, on the contrary, had as a consequence to fade out his potential role in the theory.

Further Developments

In their reaction to Gartner (1988), Carland et al. (1988) argued that it is inappropriate to separate the process of business creation from the characteristics of the founders and entrepreneurs because both aspects are inseparably tied. In a more recent article, Carland and Carland (2000) further criticized the tendency of contemporary economics to favor statistical reasoning and mathematical models, instead of exploratory study, which as a consequence tends to neglect the individual level of entrepreneurship, pushing the entrepreneur out of the explanation model. They suggest on the contrary to pay more attention to the entrepreneur's characteristics and reasoning and to the cognitive process leading to venture creation. This would mean to take into account the individual "entrepreneurial psyche" which may be conceived "as a gestalt of multiple personality factors" (traits, cognitive styles, entrepreneurial drives). Such an argumentation finally may also offer a solution to the problem of differentiating the entrepreneur from non-entrepreneurs, since it does not necessarily imply a dichotomous vision (entrepreneur vs. non-entrepreneur) but allows to interpret the phenomenon as a relative one, which means that it would be compatible with the observation that entrepreneurship can manifest itself in quite heterogenous forms.

While the scientific debate in the 1980 produced an important movement for questioning the common psychological approach of the entrepreneurial personality used at that time, that is, the widespread focus on the psychological traits of the entrepreneur, later research was characterized by attempts to reequilibrate the psychological traits and behavioral perspectives. This meant to bring back the entrepreneur into the theoretical explanations and to develop more complex models which would take into account as well the role of personality as the contextual factors affecting entrepreneurship.

The new trends in research on the psychological aspects of entrepreneurship, after the conflictual debate of the 1980s, went toward the development of more interactionist and cognitive approaches (Chell 2008: 142 ff.). Regarding the different topics studied, Chell (2008: 171) mentions, among others, the cognitive research on heuristics or shortcuts, cognitive scripts, cognitive biases (e.g., illusion of control), overconfidence, errors in decision making, self-efficacy (feeling/perception of personal efficacy), regretful thinking and feelings of disappointment, opportunity recognition and evaluation, and social and cognitive aspects of creativity.

The knowledge developed through this research suggests that if the entrepreneur's psychological dispositions may have some roots in innate traits, the interaction with others, as well as cognitive and social learning processes, plays a decisive role with regard to the construction of the entrepreneurial personality. The scientific field here is rather differentiated, different theoretical schools contributing to the ongoing scientific debate. According to Chell (2008: 204), four major categories of theories can be distinguished: trait theory, social constructionism, social cognitive theory, and social psychological theories.

While trait theory supposes the existence of some, in the middle term, relative stable, behavioral patterns – independently from the question if these are inborn and/or developed throughout primary and secondary socialization (especially during the process of entrepreneurial experience) and more or less independent from situational influences – the other approaches relativize the role attributed to individual, in comparison to contextual and process factors, by linking, in different ways, both dimensions.

The social constructionist approach, for example, is based on the idea that entrepreneurs are not socially isolated individuals. On the contrary, it postulates that the entrepreneurial personality is much a social construction which is permanently created and recreated through social interaction and interpersonal discourse.

Social cognitivist approaches, in comparison, focus especially on the cognitive dimension of entrepreneurial behavior. The consistency of this latter is interpreted as an effect of the cognitive structures in long-term memory (context-specific

social knowledge, beliefs, motivations, socially learned behavior, procedural skills, etc.). Again, this perspective tends somewhat to stress the static elements of entrepreneurial behavior and to attribute less attention to its dynamic aspects.

Finally, the fourth category of approaches enumerated by Chell (2008: 204), the social psychological perspective, is different in this respect: Under this theoretical angle, the dynamics resulting from the interaction with the social and institutional environments are conceived as being relatively more important and even central. In this approach, environmental influences are seen to be decisive, especially for the self-development of the entrepreneur.

Recent and current research continues to be interested in the link between personality and entrepreneurship, representing a particular research strategy to approach the psychological aspects of entrepreneurial dynamics. A recent example is the *Journal of Economic Psychology* and its decision to edit a special issue on "Personality and Entrepreneurship" (Journal of Economic Psychology, Vol.33, issue 2, April 2012).

Besides that, the cognitive dimension is still studied by numerous scholars, a rather dynamic research field comprising (and being open to) many different topics (e.g., entrepreneurial cognition, cognitive adaptability, entrepreneurial opportunity recognition and evaluation, entrepreneurial decision making, entrepreneurial intentions, and cognitive motivations).

Finally, another type of research work not mentioned yet, but of certain interest for the topic developed here, concerns the organizational level of entrepreneurship as the aggregate level of individual entrepreneurial behavior. An important indicator for the development of this type of work is the increasing number of research realized during the last years on "entrepreneurial orientation" (firms with entrepreneurial orientation are seen to be characterized by proactiveness, autonomy, innovation, risk taking). While the focus is on organizational issues and firm-level entrepreneurial behavior, it can be easily imagined that the organizational level, being the social arena for human action, is indirectly influenced by the psychological processes initiated on the micro- and intermediate levels of entrepreneurs and entrepreneurial groups.

Conclusion and Future Directions

Psychology plays an important role in entrepreneurial processes, since their basis are *human interactions*. However, it proved to be a challenging task in the past to develop theoretical models allowing to seize appropriately the psychological aspects of entrepreneurship. Important advances in academic knowledge have been realized during the past decades, with different theoretical focus. A very general trend in research seems to be the evolution away from the classical trait models of the 1980s toward more interactionist and/or cognitive approaches. An important point is that this does not necessarily imply questioning the potential role played by personal characteristics of the entrepreneur. On the contrary, current research again is considering the integration of these aspects into the theoretical models.

Cross-References

- ▶ Cognition of Creativity
- ▶ In Search of Cognitive Foundations of Creativity
- ▶ Creative Personality
- ▶ Creativity and Emotion
- ▶ Imagination
- ▶ Individual Determinants of Entrepreneurship
- ▶ Psychology of Creativity
- ▶ Social Psychology of Creativity

References

Aldrich HA. Organizations evolving. London/Thousand Oaks/New Delhi: Sage; 1999.

Carland JA, Carland JW. New venture creation model. J Bus Entrepr. 2000;12(3):29–48.

Carland JW, Hoy F, Carland JA. "Who is an entrepreneur?" Is a question worth asking. Am J Small Bus. 1988;12(4):33–9. Spring.

Chell E. The entrepreneurial personality. A social construction. 2nd ed. Hove (East Sussex)/New York: Routledge; 2008.
Gartner WB. "Who is an entrepreneur?" Is the wrong question. Am J Small Bus. 1988;12(4):10–32. Spring.
Gartner WB. Some suggestions for research on entrepreneurial traits and characteristics. Entrep Theory Pract. 1989;14(1):27–37. Fall.
Gartner WB, Shaver KG, Carter NM, Reynolds PD, editors. Handbook of entrepreneurial dynamics: the process of business creation. Thousand Oaks/London/New Delhi: Sage; 2004.
Krueger NF. The cognitive psychology of entrepreneurship. In: Acs ZJ, Audretsch DB, editors. Handbook of entrepreneurship research. New York: Springer; 2003. p. 105–40.
Lazzarato M. Puissances de l'invention: la psychologie économique de Gabriel Tarde contre l'économie politique. Paris: Les empêcheurs de penser en rond; 2002.

Psychological Determinants

► Individual Determinants of Entrepreneurship

Psychology of Creativity

Liane Gabora
Department of Psychology, University of British Columbia Okanagan Campus, Kelowna, British Columbia, Canada

Synonyms

Creativity research; Empirical aesthetics; Empirical studies of creativity; Empirical studies of the arts

Key Concepts and Definition of Terms

Defining Creativity

Creativity is arguably our most uniquely human trait. It enables us to escape the present, reconstruct the past, and fantasize about the future, to envision something that does not exist and change the world with it. The elusiveness of the construct of creativity makes it that much more important to obtain a satisfactory definition of it. Defining creativity presents difficulties; for example, not all creative works are useful, and not all are aesthetically pleasing, though both usefulness and aesthetic value capture, in some sense, what creativity is about. Nevertheless, psychologists have almost universally converged on the definition originally proposed by Guilford over 60 years ago. Guilford (1950) defined creativity in terms of two criteria: *originality* or novelty, and *appropriateness* or adaptiveness, i.e., relevance to the task at hand. *Surprise* is sometimes added as a third criterion (Boden 1990). Some add *quality* as a separate criterion (Kaufman and Sternberg 2007), while others use the term appropriateness in a way that encompasses quality. Creativity has also been defined as a complex or syndrome, and some would insist that any definition of creativity include such cognitive and personality characteristics as problem sensitivity, flexibility, and the ability to analyze, synthesize, evaluate, and reorganize information, engage in divergent thinking, or deal with complexity. However, it is the "originality and appropriateness" definition that is encountered most often and that appears to have become standard (e.g., Amabile 1996; Feldman et al. 1994; Runco 2004; Sternberg 1988). While this definition provides a much-needed departure point for discussion about and measurement of creativity, there is probably no one-size-fits-all definition of creativity. For scientific or technological enterprises, appropriateness might be more important, whereas in the arts, originality might be weighted more heavily. Thus, creativity must be assessed relative to the constraints and affordances of the task.

The Four P's of Creativity

It is often said that creativity involves four P's: person, process, product, and place. The creative *person* tends to exhibit certain personality traits. Creativity is correlated with independence of judgment, self-confidence, attraction to complexity, aesthetic orientation, risk taking,

openness to experience, tolerance of ambiguity, impulsivity, lack of conscientiousness, and high energy. There is some evidence that creative individuals are more prone to anxiety and affective disorders. Creative individuals differ with respect to whether they are internally versus externally oriented, person-oriented or task-oriented, and explorers (who tend to come up with ideas) or developers (who excel at turning vague or incomplete ideas into finished products).

A pioneering effort toward demystifying the creative *process* was Wallas' (1926) classification of the creative process into a series of stages. The first of Wallas' stages is *preparation,* which involves obtaining the background knowledge relevant to the problem, its history (if known), and any instructions or past attempts or preconceptions regarding how to solve it. It also involves conscious, focused work on the problem. The second stage is *incubation* – unconscious processing of the problem that continues while one is engaged in other tasks. The preparation and incubation stages may be interleaved, or incubation may be omitted entirely. Wallas proposed that after sufficient preparation and incubation, the creative process is often marked by a sudden moment of *illumination*, or insight, during which the creator glimpses a solution to the problem, which may have to be worked and reworked in order to make sense. The idea at this point may be ill defined, "half baked," or in a state of *potentiality*; the ability to work with an idea in this state is related to the personality trait of tolerance of ambiguity. Wallas' final phase is referred to as *verification*. This involves not just fine-tuning the work and making certain that it is correct, as the word implies, but putting it in a form that can be understood and appreciated by others.

The creative *product* can take the form of a physical object (e.g., a painting), or behavioral act (e.g., a dance), or an idea, theory, or plan of action.

The last of the four P's of creativity, *place*, concerns the environmental conditions conducive to creativity. Certain individual situations, such as education and training, role models and mentors, and perhaps surprisingly, childhood trauma, are correlated with historical creativity. Economic growth appears to have a stimulating effect on creativity, whereas war appears to have a depressing effect.

Historical Versus Personal Creativity

Although the term "creative" is often reserved for those who are known for their creative output, some make the case that daily life involves thinking things and doing things that, at least in some small way, have never been thought or done before and, thus, that *everyone* is somewhat creative (Beghetto and Kaufman 2007; Runco 2004). Psychologists now distinguish between different kinds and degrees of creativity, such as between historical and personal creativity (Boden 1990). When the creative process results in a product that is new to all of humanity and makes an impact on the course of civilization, it is referred to as *historical creativity* (H-Creativity). Historical creativity is also sometimes referred to as *eminent creativity* because the creator tends to become famous. When the creative process results in a product that is new to the creator, but someone else has come up with it before, or it is not creative enough to exert an impact on human civilization, it is referred to as *personal creativity* (P-Creativity). Although personal creativity does not change the world, it can be a source of pleasure and amusement. Clearly there are shades of gray between these extremes.

A concept that is closely related to personal creativity is *everyday creativity*. Everyday creativity manifests in everyday life; it comes through in how one prepares a meal, decorates a room, or interprets and shares experiences. Everyday creativity generally begins with an innovative, often unconventional approach to life that involves capitalizing on hidden opportunities, undertaking common tasks in uncommon ways, and finding unique solutions to challenges as they arise.

Historical and personal creativity are also sometimes referred to as *Big C creativity* and *Little C creativity*, respectively. Some additionally make the case for *Mini*

C creativity, which involves making novel and personally meaningful interpretations of objects and events, and which can form the basis for more substantial creative acts (Beghetto and Kaufman 2007).

Creativity Versus Discovery and Invention

Creativity is sometimes distinguished from two related concepts, discovery and invention. *Discovery* involves finding something *already present* and sharing it, e.g., Columbus' discovery of America. It is relatively impersonal in the sense that if one person had not discovered it, someone else would have. *Invention* entails unearthing something that was *not present before,* e.g., Alexander Bell's invention of the telephone. Like discover, it is relatively impersonal. Creativity also involves unearthing and sharing something that was not present before. Some psychologists additionally require that for something to qualify as creative, it must be profoundly personal in the sense that one feels the presence of a unique individual in the work, e.g., Leonardo da Vinci's art.

Theoretical Background and Open-Ended Issues

Early Conceptions

In early times the creative individual was viewed as an empty vessel that was filled with inspiration by a divine being. Psychologists initially paid little attention to creativity because it was thought to be too complex and frivolous for scientific investigation. Freud believed that creativity results from the tension between reality and unconscious wishes for power, sex, love, and so forth. While this view is not as prominent now as it was in his time, his notion of the *preconscious* – a state between conscious and unconscious reality where thoughts are loose and vague but interpretable – is still viewed by many as the source of creativity. The year 1950 marks a turning point for psychological interest in creativity, when it was the subject of Guilford's address to the American Psychological Association.

Current Psychological Approaches to Creativity

Creativity is now of interest to many disciplines and approached from many directions. Even within the discipline of psychology, it is addressed in a variety of ways. Cognitive psychologists study cognitive processes considered to be creative, such as analogy, concept combination, and problem solving, and they write computer programs that simulate these processes (e.g., Finke et al. 1992). Those who take a psychometric approach develop tests of creativity, the most widely known being the Torrance Test of Creative Thinking (Torrance 1974). Examples of such tests are the *Unusual Uses Test* in which participants are asked to think of as many uses for a common object (e.g., a brick) as possible, or the Product Improvement Test, in which participants are asked to list as many ways as they can to change a product to make it more useful or desirable (e.g., to change a toy monkey so children will have more fun playing with it). Developmental psychologists study creativity in children and throughout the lifespan. Social psychologists examine how family dynamics, group dynamics, and cultural influences affect creativity. Clinical psychologists look at how art therapy, music therapy, and dance therapy can help patients open up and express themselves in ways that verbal communication may not. Neuroscientists investigate the biological basis of creativity. Organizational psychologists study creativity as it pertains to entrepreneurship and successful business strategies. Finally, comparative, evolutionary, and cultural psychologists address the question of how humans came to possess their superlative creative abilities, how these abilities compare with those of other species, how creativity compares across different cultures, and in what sense creative ideas can be said to evolve over time.

The Relative Contributions of Expertise, Chance, and Intuition

While most psychologists believe that creativity involves a combination of expertise, chance, and intuition, they differ with respect to the degree of emphasis they place on these factors.

Expertise theorists point to evidence that it takes approximately a decade to master a creative domain (Hayes 1989). Experts are better than beginners at detecting and remembering domain-relevant patterns and are more adept at generating effective problem representations and, when necessary, revising initial hypotheses. Expertise theorists posit that creativity involves everyday thought processes such as remembering, planning, reasoning, and restructuring. They claim that no special or unconscious thought processes are required for creativity, just familiarity with and skill in a particular domain (Weisberg 2006).

Critics of this view note that entrenchment in established perspectives and approaches may make experts more prone than beginners to set functional fixedness and confirmation bias. Those who emphasize the role of *chance* include advocates of the Darwinian theory of creativity, according to which the creative process, like natural selection, entails blind generation of possibilities followed by selective retention of the most promising of them (Simonton 1999).

Other psychologists view creativity as not so much a matter of generating and selecting among predefined alternatives but of intuiting an idea and then, by considering the idea from different perspectives or trying it out different ways, taking it from an ill-defined state of potentiality to a well-defined state of actualization (Gabora 2010). Those who emphasize the actualization of potentiality and the role of *intuition* emphasize the association-based structure of memory and note that creative individuals tend to have *flat associative hierarchies,* meaning they have better access to *remote associates*, items that are related to the subject of interest in indirect or unusual ways.

The Relative Importance of Process Versus Product

To many it seems natural to value the creative process for the products it gives rise to; indeed creative products have significantly transformed this planet. Others view the creative process itself as more important than the product. They stress the *therapeutic value of creativity*. In this view the primary value of the creative process is that it enables the creator to express, transform, solidify, or unify the creator's understanding of and/or relationship to the world, while the external product provides a means of tracking or monitoring this internal transformation. This view is more prominent in Eastern than Western cultures. It also figures prominently in creative therapies such as art therapy, music therapy, and drama therapy.

Is Creativity Domain Specific or Domain General?

Psychologists who emphasize the role of expertise tend to view creativity as highly *domain specific;* expertise in one domain is not expected to enhance creativity in another domain. They note that expertise or eminence with respect to one creative endeavor to be only rarely associated with expertise or eminence with respect to another creative endeavor (Baer 2010). For example, creative scientists rarely become famous artists or dancers.

Psychologists who emphasize intuition and associative processes, on the other hand, tend to view creativity as somewhat *domain general* because associative thinking can result in metaphors that connect different domains. Studies involving self-report scales, creativity checklists, and other sorts of psychometric or personality data tend to support the view that creativity is domain general (Plucker 1998). The relevance of these studies to the general versus specific debate has been questioned because they do not actually measure creative outputs but rather traits associated with the generation of creative output. However, those who stress process over product claim that these data tell us about the internal, less visible, but equally important counterpart to the *external* manifestations of the creative process. An emphasis on product rather than process may have resulted in exaggeration of the extent to which creativity is domain specific. That is, if one asks not, "are individuals talented in multiple creative domains?" but, "can individuals use multiple creative domains to meaningfully develop, explore, and express themselves?" the

answer is more likely to be affirmative. Most psychologists believe that the truth lies somewhere between the extremes. That is, creativity in one domain may help but not guarantee creativity in another; it is neither strongly domain specific nor domain general.

Is There a Dark Side to Creativity?

Although creativity is clearly stimulating and indispensable to cultural and technological advancement, many believe it has a dark side (Cropley et al. 2010). There is considerable evidence that eminent creativity is correlated with proneness to affective disorders, suicide, and substance abuse. Moreover, it is not necessary for everyone to be creative. We can all benefit from the creativity of a few by imitating, admiring, or making use of their creative outputs. Excessive creativity may result in reinventing the wheel, and absorption in ones' own creative ideas may interfere with assimilation or diffusion of proven effective ideas. Computer modeling suggests that society self-organizes to achieve a balance between relatively creative and uncreative individuals (Leijnen and Gabora 2009). The social discrimination that creative individuals often endure until they have proven themselves may aid in achieving this equilibrium.

Implications for Theory, Policy, and Practice

The psychology of creativity has implications for theory, policy, and practice in a number of arenas. A first area of application is clinical. Creative activities such as art making, music making, dance, and drama are increasingly seen to have therapeutic effects that can be effective in both clinical and nonclinical settings. The transformation that occurs on canvas or on the written page is thought to be mirrored by a potentially therapeutic sense of personal transformation and self-discovery that occurs within. Immersion in the creative task has been referred to as a state of *flow* that may share characteristics with deeply spiritual or religious experiences.

A second, related area of application is child rearing and education. For example, creative play in childhood facilitates access to affect-laden (emotional) thoughts, which may enhance cognitive flexibility and divergent thinking abilities. Amabile's (1996) work on *intrinsic motivation* showed that rewards for creative work may actually inhibit creativity because focusing on an external reward leads people to neglect the internally rewarding nature of creative acts.

A third area of application is in business settings. For example, psychological work on *brainstorming sessions*, in which people get together as a group and put forward ideas in an open and accepting environment, has shown that it may be more effective when group work is followed immediately by individual work or when individuals communicate by writing so as to avoid the problem of everyone talking at once.

Conclusion and Future Directions

It is our creativity that perhaps most distinguishes humans from other species and that has completely transformed the planet we live on. The psychological study of creativity is an exciting area that brings together many different branches of psychology: cognitive, developmental, organizational, social, personality, clinical, neuroscience, and even computational and mathematical models. Past and current areas of controversy concern the relative contributions of expertise, chance, and intuition, whether the emphasis should be on process versus product, whether creativity is domain specific versus domain general, and the extent to which there is a dark side to creativity. Promising areas for further psychological study of creativity include computational modeling and work on the neurobiological basis of creativity as well as environmental influences on creativity.

Cross-References

► Creativity Research

References

Amabile T. Creativity in context. Boulder: Westview Press; 1996.

Baer J. Is creativity domain specific? In: Kaufman J, Sternberg R, editors. Cambridge handbook of creativity. Cambridge, UK: Cambridge University Press; 2010. p. 321–41.

Beghetto RA, Kaufman JC. Toward a broader conception of creativity: a case for "mini-c" creativity. Psychol Aesthetic Creativity Arts. 2007;1(2):73–9.

Boden MA. The philosophy of artificial intelligence. New York: Oxford University Press; 1990.

Cropley D, Cropley JK, Runco M, editors. The dark side of creativity. Cambridge, UK: Cambridge University Press; 2010.

Feldman DH, Csikszentmihalyi M, Gardner H. Changing the world: a framework for the study of creativity. Westport: Praeger; 1994.

Finke RA, Ward TB, Smith SM. Creative cognition: theory, research, and applications. Cambridge, MA: MIT Press; 1992.

Gabora L. Revenge of the "neurds": characterizing creative thought in terms of the structure and dynamics of human memory. Creativity Res J. 2010;22(1):1–13.

Guilford JP. Creativity. Am Psychol. 1950;5:444–54.

Hayes JR. Cognitive processes in creativity. In: Glover JA, Ronning RR, Reynolds CR, editors. Handbook of creativity. New York: Plenum Press; 1989. p. 135–45.

Kaufman JC, Sternberg RJ. Resource review: creativity. Change. 2007;39:55–8.

Leijnen S, Gabora L. How creative should creators be to optimize the evolution of ideas? A computational model. Elect Proc Theor Comp Sci. 2009;9:108–19.

Plucker JA. Beware of simple conclusions: the case for the content generality of creativity. Creativity Res J. 1998;11:179–82.

Runco MA. Creativity. Annu Rev Psychol. 2004;55:657–87.

Simonton DK. Creativity as blind variation and selective retention: is the creative process Darwinian? Psychol Inq. 1999;10:309–28.

Sternberg RJ. A three-faceted model of creativity. In: Sternberg RJ, editor. The nature of creativity. Cambridge, UK: Cambridge University Press; 1988. p. 125–47.

Torrance EP. The Torrance tests of creative thinking. Princeton: Personnel Press; 1996.

Torrance EP. Torrance tests of creative thinking-norms and technical manual. Lexington, Massachusetts: Ginn, 1974.

Wallas G. The art of thought. London: Cape; 1926.

Weisberg RW. Creativity. New York: Wiley; 2006.

Public Policy

► Entrepreneurship Policies

Public-Private Partnerships for Research and Technological Development (PPP RTD)

► Mode 3 Knowledge Production in Quadruple Helix Innovation Systems: Quintuple Helix and Social Ecology

Puzzle

► Creativity in Puzzles, Inventions, and Designs: Sudden Mental Insight Phenomenon