Innovation Policy and Design Thinking

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Abstract

This paper presents the basis for the connection between design thinking, innovation and innovation policy. It suggests that designing needs to be considered within a wider ambit than that of the designer and direct client and that much designing is for consumers who are not the direct clients of the designer. The paper draws the distinction between the producers of intellectual property, the innovators who use that intellectual property and who, through designing, generate products that are adopted by consumers. The relationship of the these players is a social one in that many of their interactions are not direct but are indirect, and that these interactions affect their future behavior and the resulting phenomenological behavior of the system as a whole.

The paper presents the outline of an architecture of a system based on computational social science, to study the relationship between designing, innovation and innovation policy and the behavior of funders of intellectual property, producers of intellectual property, funders of innovators, innovators as designers and consumers of innovative products.

1. Introduction

Design research has largely treated designing as an activity involving a single designer or a team of designers commencing with requirements set by a client. The focus has been on the processes that a designer utilizes to generate a design. These processes are deemed to be examples of design thinking – that unique class of thinking that distinguishes designing from other human activity. The primary means of studying designing can be broken into two classes: computational modeling and cognitive studies, with the former predating the latter.

Computational models of designing have treated designing as an algorithmic process. The algorithms have been based either on conjectures about human designing behavior or on processes unrelated to humans. Examples of the former category include analogy and case-based reasoning processes. Examples of the latter category include evolutionary algorithms and neural networks. Computational models so far have drawn their inspiration primarily from either operations research or artificial intelligence (Asimov 1962; Buede 1999; Dym 1994; Gero 1991; Gero 2008; Pahl et al 2007; Radford and Gero 1988).

Cognitive studies of designing have used an increasing array of approaches commencing with questionnaires and input-output experiments, with the primary method currently being based on protocol analysis (Ericsson and Simon 1993; van-Someran et al 1994). Future methods are likely to be based on cognitive neuroscience (Alexiou et al 2010)).

In all of this research aimed at illuminating design thinking insufficient attention has been given to the place of designing in the production of value in a society. Among a nation's goals are competitive leadership in the international marketplace and excellence in innovation and productivity. Innovation based on creative or at least superior design, a fundamental prerequisite for superior products and systems, is one of the keys for achieving these goals. The aim of this paper is to place designing within the context of innovation and the larger framework of innovation policy. The paper will only present an overall description of this framework.

To commence we draw the distinction between creation, designing and innovation as all three terms, or their derivatives, are often used interchangeably. We will use the term "creation" to apply to the generation of intellectual property that is novel, useful and unexpected. This intellectual property can be in the form of concepts found in research papers, licences, patents or designs (Boden 2003; Gero 1990; Gero and Maher 1993; Runco 2006; Sawyer 2006; Sternberg 1998). We will use the term "designing" to denote that activity that involves the production of consumable artefacts. We will use the term "innovation" to denote the introduction or uptake of intellectual property into products, processes or markets to create value from those products or processes (Archibugi et al 1999; Edquist 1997). Designing may or may not be involved in the production of intellectual property but is always involved in innovation. The distinction between these three terms and what they imply is important as it is argued that the generation of products and processes is a separate activity from their introduction or uptake although the three are co-related (Hybs and Gero 1992). Innovation policy is any policy targeted at improving innovation.

We define "design thinking" as the process by which a designer creates an expected world different from the current world, operates within that world to produce a design and then brings the design in that expected world and the current world together. From this point of view the production of intellectual property can also be seen to be a kind of design thinking.

2. Designing, innovation and innovation policy

Designing is sometimes carried out for individual clients who are the end users of those designs, but mostly it is carried out for clients who are innovators producing artefacts for third parties here called “consumers”. Economic models of innovation have been developed along with computational implementations (Anderson 1994; Leydesdorff 2000; Moldovan and Goldenberg 2004; Nelson 2002). Recent research into innovation and innovation policy has produced interesting results along with models that are often untestable (Akintoye and Beck 2008; Allen et al 1983; Archibugi et al 1999; Branscomb and Keller 1999; Edquist 2005; Llerena and Mireille 2005). Currently there is no adequate, scalable, testable model of innovation policy.

The domain-individual-field-interaction (DIFI) model of creativity by Feldman et al (1994) provides a framework through which we can explain the interactions between different players and the production of artefacts. Innovation clustering and the emergence of groups of innovations in geographic regions has been studied (Avermaete et al 2003; Azagra-Caro et al 2007; Cooke 2001).

2.1 Schumpeter

Schumpeter, in his landmark opus *Capitalism, Socialism and Democracy* (Schumpeter 1942), introduced a concept he claimed was a fundamental part of the foundation of capitalism and one of the primary causes of its success. He called this concept “creative destruction”.

“... the same process ... that incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. ... the problem that is usually being visualized is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them.” (Schumpeter 1942, pp. 83-84.)

This is a profound theory of innovation that, it is claimed, can form the basis of innovation policy. At this abstract level it draws the distinction between the evolution of products, processes and markets being treated as Darwinian systems and being treated as Lamarckian systems. In the Darwinian metaphor systems evolve with small changes and changes to the organism do not affect its genome or fitness function, where the genome may be thought of as the producer of the organism and the fitness function is the way in which it is evaluated in some market. This form of evolution matches the notion of optimization. In the Lamarckian metaphor, changes to the organism cause disruptions to the genome with the resulting displacement of the previous organism. In addition to disrupting the genome there are also changes to the fitness function, ie, the value system used to evaluate the organism. This form of evolution matches the notion of designing and has the potential to produce transformation. Creative destruction as a model of innovation results in a transformation rather than incremental change. It does so by destroying what was there before and substituting it with another, more creative one, Figure 1.

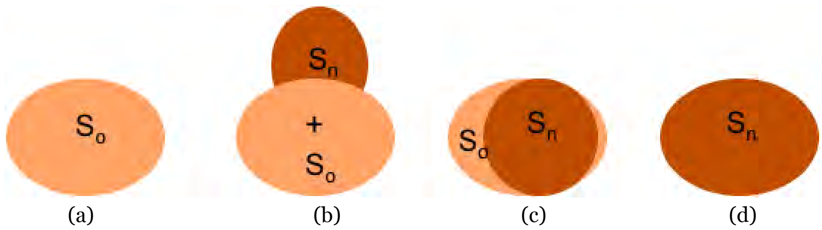

Figure 1. (a) Original world, S_o, (b) new world, S_n, is additive in relation to the existing world, S_o; (c) new world, S_n, displaces part of existing world, S_o; (d) new world, S_n, displaces all of existing world, S_o.

An innovation policy for a system would be one that results in an improvement in innovation and would include this transformative behavior of the system. This class of behavior is an emergent, phenomenological result of the system rather than a direct consequence of entering data into formulas. It is claimed that the behavior of interest is phenomenological since we have no causal models that would form the basis of a computational implementation. So the questions arises: how can such a phenomenological view be tested? The remainder of this paper outlines an approach to answering this question.

2.2 Modeling innovation and innovation policy

How can we model such an abstract concept in a manner that the contributions of the various inputs, phenomena and the resulting system's behavior can be inspected and tested? We need to be able to build a "laboratory" where all the variables can be represented, where the resulting interactions between the variables can occur and the consequential, emergent phenomenological behavior made available. Once we do this we can then experimentally study the effects of variables on the production of transformative behavior and induce an innovation policy from this emergent behavior (Kuhn 1996; Thomke 2003).

To reify this we need to draw on a panoply of ideas and methods from the domains of:

innovation theory
creative production/design thinking
computational social science
social multi-agent systems
situated cognition
emergence.

Each of these domains will be briefly introduced and their contributory roles described.

Innovation Theory: the conceptual basis of innovation; of interest here is the theory based on creative destruction (Scherer 1984; Schumpeter 1942), later sometimes termed disruptive innovation (Bower and Christensen 1995; Danneels 2004). This provides the foundational ideas for the transformative behavior of systems. The significance of Schumpeter's theory of innovation is that it implies not only that products are displaced but, more importantly, that these new products bring new values with them that change the way all displaced and future products will be evaluated. We will describe how this can be modeled using ideas from situated cognition.

Creative production/design thinking: this requires processes that have the capacity to produce novel, useful and unexpected results; we will draw on the research in creative designing and design thinking to model this (Gero 2000; Gero and Maher 1993; Taura and Nagai 2005). We will describe how creative production is ultimately social (Csikszentmihalyi 1996; Feldman et al 1994; Sosa and Gero 2005). Creative production is the progenitor of innovation.

Computational social science: this models social interactions and simulates the resulting social behavior through the use of computational agents rather than equation-based methods (Castelfranchi 2001; Casti 1999; Epstein 2007; Epstein and Axtell 1996; Gilbert and Conte 1995; Gilbert and Doran 1994; Hegselmann et al 1996; Macy and Willer 2002; Miller and Page 2007). Computational social science provides the conceptual substrate for the development of this laboratory.

Social multi-agent systems: computational agents are encapsulated computer programs that respond and behave autonomously (Ferber 1999; Jennings and Wooldridge 1998; Weiss 2000; Wooldridge 2002). They can model any system that has goals, beliefs and methods or processes to move towards those goals. They can interact with their environment and other agents. Here they will be used to model different players in a system capable of innovation (Gilbert and Doran 1994; Sosa and Gero 2004; Sosa and Gero 2007). The internal state of social agents includes individual and collective components that gradually go from the individual to group structures such as pair, team, group, community, class, and finally to a society. Social multi-agent systems provide the implementation substrate for the development of this laboratory.

Situated cognition: this set of concepts holds that what you think the world is about affects what it is about for you, ie any system operates within its own world view and that world view affects its understanding of its interactions with its environment (Dewey 1896/1981; Clancey 1997). When we say an agent is “situated” (Smith and Gero 2005) we mean that it has a world view that is based on its experience – rather than using the AI meaning that it is embodied in an environment. Being situated is the fundamental construct that allows for the modelling of the changes of the value system brought about by creative destruction.

Situations are the result of being situated and may be thought of as the set of concepts and their relationships that embody the ontology of the world under consideration. This ontology includes the value systems that build expectations about the behavior of the world and are used to take decisions in that world (Gero and Kannengeisser 2004). Changing situations changes the value system of the world and can change the world itself (Gero and Kannengeisser 2009). Situations can change in one of three ways to produce a change in value system:

- concepts can be added or deleted;
- relationships between existing concepts can be added, deleted or modified in strength; or
- concepts can be substituted either for a subset of existing concepts or for all existing concepts.

Emergence: this is the notion that structures or behaviors can be found in a system that were not intentionally put there, ie, they emerged (Finke 1996; Gero 1996; Gero and Damski 1996; Gilbert 2002; Goldstein 1999; Holland 1999; Johnson 2001; Smith and Gero 2001). Computational social science, using multi-agent systems, often aims to demonstrate the emergence of behaviors such as acculturation, groupings, and diffusion, which are a systemic consequence rather than a direct consequence of causal knowledge embodied in predictive equations.

An innovation policy will be an emergent property of the behavior of the system based on the data produced by the simulations carried out in this laboratory.

3. Studying designing, innovation and innovation policy

This paper has argued that designing needs to be viewed within a broader canvas and that design thinking can occur not only at the level of the individual designer or design team but also may be part of the production of intellectual property. Further, designing plays a role in innovation by drawing on existing intellectual property to produce innovative artefacts that are adopted by consumers who are not the direct clients of the designer. Innovation is partly influenced by innovation policy and as a consequence there is a relation between designing and innovation policy. Section 2 has presented an outline of the tools that are required to study such a broad view of designing, innovation and innovation policy. This section briefly introduces the players that go to make up a system that has innovators, who employ designers, at its core.

3.1 Players

The primary players that inhabit this landscape and variously interact with each other are the following.

Producers of intellectual property: these are researchers in universities, research institutes and research centers of companies; designers who work directly for individual clients can also produce intellectual property.

Funders of intellectual property producers: these are government agencies and private foundations as well as the research arms of commercial organizations.

Innovators: these are companies that own, collect, license and purchase intellectual property and, through the deployment of capital, design products that claim to be innovative.

Venture capitalists: these are funders of innovators.

Consumers: these are the people and organizations that purchase the products of innovators.

In addition to the primary players there are secondary players that interact with the primary players, and include the following.

Marketers: these are people and organizations that are contracted by the innovator of a product to magnify its reach with consumers.

Amplifiers: these are people and organizations that are not associated with either the product or the innovator that through their commentary on the product amplify its reach. Typically they are columnists or reviewers in newspapers, journals, websites and blogs.

Gatekeepers: these are people and organizations that are not associated with either the product or the innovator that have the capacity to limit the notifications about the product. In physical stores they are the ones who decide whether to stock a product. Gatekeeping also applies to the dissemination of research results. In this case they are journal editors and conference program directors.

3.2 Objects

In addition to players who perform an active role there are objects that are the exogenous input to various players and the endogenous output of players and the system phenomenological behavior. The objects in this system are:

Government policies: typical policy instruments that affect innovation include taxation policies, financial policies, regulatory policies, educational policies and migrational policies.

Research funding proposals: producers of intellectual property generate funding proposal that they submit to funding agencies.

Intellectual property: this is the output of the producers of intellectual property.

Venture capital proposals: innovators generate funding proposals that they submit to venture capitalists.

Products: innovators produce products.

Consumer behavior: this is part of the system phenomenological behavior of unique importance as it is used to define the success or otherwise of products and is usually measured as the aggregation of the individual consumer's purchase of particular products.

System phenomenological behavior: this is endogenous, collected and collated output from parts or all of the system and include emergent behavior.

Figure 2 shows the players and objects that go to make up the system. Of particular interest is how these players and objects interact with each other. For this we need computational social science modeling.

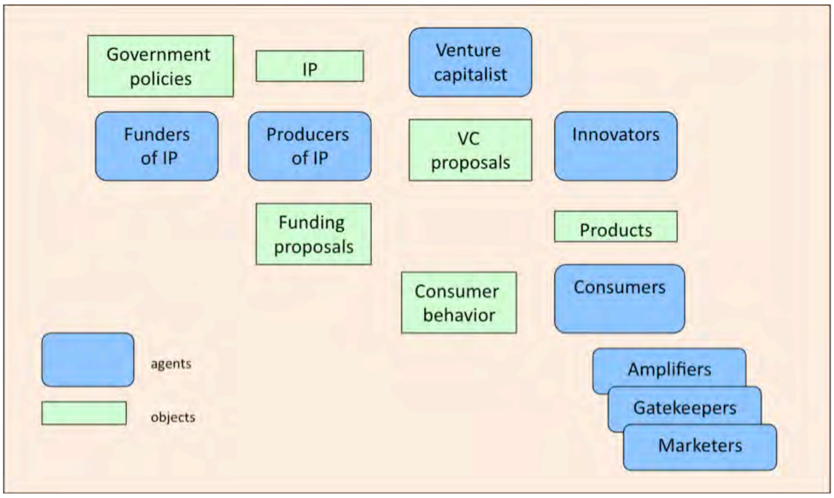

Figure 2. The players as agents and objects that make up the system.

4 Computational social science modeling of designing, innovation and innovation policy

4.1 Agent modeling

A computational social science model of designing, innovation and innovation policy commences with the primary players and models each as a set of social, situated cognition agents in an environment such as MASON (http://www.cs.gmu.edu/~eclab/projects/mason/). MASON is a fast discrete-event multi-agent simulation library core in Java, designed to be the foundation for large custom-built Java simulations. All agents embody situated cognition through their ability to change their value systems based on their social interactions with other agents and the environment. All agents are social in that they respond to direct and indirect interactions with other agents. Direct interactions occur when one agent sends a message to another agent. Indirect interaction occurs when an agent either observes the behavior of another agent or observes some systemic behavior or some object in its environment. Each player agent can interact with and observe agents of the same kind of player as itself or other kinds of players. Each player has the ability to observe a limited range of objects.

4.2 Primary players' direct and indirect interactions

The direct an indirect interactions among players and between players and objects generate the social model of the system through those interactions. The level and influence of these interactions are endogenous variables in this system.

Funders of IP: these directly interact with government policies and directly with producers of IP who generate funding proposals. They change their values based on both exogenous inputs such as government policies and the submissions they receive from researchers and indirect interactions with other funding agencies by observing what they fund.

Producers of IP: these directly interact with funders of IP through the submission of proposals and indirectly with other IP producers through observing which are awarded funding and by observing the source of the IP is taken up by innovators. They can also interact directly with innovators who can ask them to produce specific IP.

Venture capitalists: these directly interact with government policies and directly with innovators who generate funding proposals. They change their values based on both exogenous inputs such as government policies and the submissions they receive from innovators and indirect interactions with other venture capitalists by observing what they fund.

Innovators: these interact directly with venture capitalists and indirectly with consumers, other innovators and products. The indirect interaction with consumers is through observing consumer behavior.

Consumers: they directly interact with the product and indirectly with each other by observing each other's behavior and with government policies.

The laboratory is now defined through this social modeling.

4.3 Innovation policies

Innovation policies commence as exogenous variables that influence the value systems of all the players. This laboratory can be run with varying innovation policies. As the social behavior of the system changes with changing value systems of the players based on the direct and indirect interactions of the players it becomes possible to capture that emergent behavior and look for patterns in it that have vectors (directions) associated with existing innovation policies. Those vectors can be used to produce new innovation policies. These new innovation policies can be treated as the feedback to the social model as a control system that has a phenomenological pathway in it.

5. Discussion

This paper has introduced the notion that designing needs to be viewed within a larger canvas than that of the designer or design team itself. It develops a framework that involves the producers of intellectual property that designers utilize to produce artefacts that are taken up by consumers. The activity occurs within a social interaction paradigm where all the players potentially interact with each other either directly or indirectly. An expansion of the space of players to include not just the designer and the consumer of the resulting artefact or product but also the producers of the intellectual property that designers make use of, the intellectual property producers' funders, the organization of innovators, within which designers work, that uses the intellectual property, and their funders as well as knowledge of consumer behavior.

Within this framework it becomes possible to explore the effects of varying a large number of parameters without having a causal model as the effects are phenomenological and emergent. The phenomenological behavior is a consequence of changing situations within a situated cognition view and of social interactions between the players. Design thinking is located within two production entities: producers of intellectual property and producers of artefacts. Traditional design has focused exclusively on the latter and has taken the view that designing is a one shot process in relation to the requirements initially set by the client. Here, designing is a continuous activity that responds to and leads the consumers of designed products. The framework can be expanded to include innovation policies and their effects on the entire process.

Design thinking becomes an integral part of the entire innovation cycle.

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