DESIGN EDUCATION IN THE INFORMATION AGE

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Keywords: Design education, Information Age, General Evolution Theory, technological change

1. Introduction

Technology is a major driver of sociocultural change. Kurzweil [2001] believes that technological change has historically followed a double exponential curve (Table 1).

<table>
<thead>
<tr>
<th>Economy</th>
<th>Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter-gathering</td>
<td>500,000</td>
</tr>
<tr>
<td>Agricultural</td>
<td>10,000</td>
</tr>
<tr>
<td>Industrial</td>
<td>200 (1760s to 1950s)</td>
</tr>
<tr>
<td>Information</td>
<td>75-80 (1940s-2020s)</td>
</tr>
<tr>
<td>Biotechnological</td>
<td>70 (1970s to 2040s)</td>
</tr>
<tr>
<td>Nanotechnological</td>
<td>70 (2020s to 2090s)</td>
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</table>

We are reaching the sharp end of this curve, with the prospect of three technological revolutions this century; the complexity and scale of these transformations is such that a 60-70 year cycle may be a minimum. We are some 50 years into the industrial/information transformation, which should mature over the next two decades. This paper speculates on the main features of design education as societies make this transformation. In doing so:

- a theoretical framework is proposed, to better understand such transformations
- this framework is used to interpret developments in design during the industrial age
- the insights so gained and the theoretical framework are then used to predict how design may change during the rest of the information age
- these insights in turn are used to anticipate how design education might develop during the rest of the information age

2. Underlying theoretical framework

A theoretical framework which sheds light equally on the past, present and future trajectories of design practice is desirable; General Evolution Theory of Ervin Laszlo [1996] is used for this purpose. Laszlo posited that all dynamic systems – physical, biological, social, cognitive – have a commonality of process; his theory is, thus, inclusive of all complex adaptive systems. We can view design practice as such a system – both in its own right and as part of the much larger systems of product/service generation and, ultimately, of socioculture itself. There are several “operational” features of Laszlo’s theory which inform the interpretational task (Table 2).
3. Design practice in the Industrial Age

The Industrial Age was accompanied by significant changes in design practice, as expressed through the emergence of design movements (Figure 1).

Recognising design practice as an evolving system, we can identify the key implications of this age for design practice as follows:

- **Informalisation**: Information accrual accelerated through the industrial age. Martin & Norman (1973:26) noted: ‘It has been estimated that by 1800 (the sum total of human knowledge) was doubling every 50 years; by 1950, doubling every 10 years; and that presently it is doubling every five years’. Although product development is often described as an exercise in information processing, it was not until the late 1980s that large UK firms recognized the need for extensive and timely access to information during product development (Fairhead, 1987:7).

- **Convergence**: From often diverse craft beginnings, convergent design practice between countries characterised the industrial age. Martin & Norman (1973:26) noted: ‘It has been estimated that by 1800 (the sum total of human knowledge) was doubling every 50 years; by 1950, doubling every 10 years; and that presently it is doubling every five years’. Although product development is often described as an exercise in information processing, it was not until the late 1980s that large UK firms recognized the need for extensive and timely access to information during product development (Fairhead, 1987:7).

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- **Divergence**: Divergence was even more evident in design education (see below).

4. Design education in the Industrial Age

There is a history of arts and crafts education in Britain which extends over at least 250 years (e.g. Biggammi, 1990). Despite growing references to design in this period, and multiple initiatives to promote design education, the discovery of an effective formula for design education was elusive. Much the same can be said for most other industrializing countries at the time. The strong influence of the fine and decorative arts and prevailing sociopolitical conditions worked against the much-needed breakthrough. It was only from late 19th century in Germany that conditions for this breakthrough appeared. With the death of William Morris in 1896, the initiative for change had passed from England to the continent and the USA. After a short interregnum, in which the USA – still largely dependent on foreign design – was unable to respond, Germany became the change-agent. A number of developments through the 1890s laid the foundations for the Bauhaus. These initiatives were reinforced by establishment of the Werkbund Education Committee in 1905. When the Bauhaus formed in 1919, it initially promoted arts and crafts ideals. It was not until 1922, and the arrival of Moholy-Nagy in 1923, that a clear and decisive shift in Bauhaus ideology towards industry became evident. The effect of wider influences on the course of events during this remarkable period is clearly evident. Following closure of the Bauhaus in 1933, many staff and students initiated similar developments elsewhere. Bauhaus ideals influenced design schools globally for another four decades or more.

**Table 2. Key features of evolving systems**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
<tr>
<td>Systems which evolve must cope with progressively larger information flows (Informalisation)</td>
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<tr>
<td>A major evolutionary strategy is convergence, leading in human affairs, to globalisation</td>
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<tr>
<td>Within the framework of convergence, divergence is an important means of creating evolutionary potential</td>
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<tr>
<td>As systems evolve, they become more complex (Complexification)</td>
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<tr>
<td>Coevolution, the interplay of collaboration and competition, is a key operational strategy in increasingly complex systems</td>
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<tr>
<td>Systems experience increasing turbulence as they approach a bifurcation (decision point); the weaker bonding, and hence greater flexibility, of complex systems is an important coping mechanism at such times</td>
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<tr>
<td>Creativity occurs particularly at the edge of chaos: as complex systems become more flexible, their creative potential increases and this creativity further accelerates their evolution</td>
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<tr>
<td>Systems seek to optimise their function at all times</td>
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<tr>
<td>As more complex social systems are more weakly bonded, there is an increasing need for social responsibility</td>
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5. Design practice in the Information Age

5.1 Introduction

We can anticipate three transformational technological events as the information age matures, each with huge consequences for design:

• the emergence of third generation communication technologies, a process already underway which should mature around 2005
• the creation of realistic virtual worlds, based on the technologies of virtual reality, augmented reality and tele-immersion, within 1-2 decades
• the realization of anytime/anyplace/multimedia communication by the 2020s

The implications of these and related developments for design are explored below.

5.2 Elemental implications

Informatization: it has recently been estimated that information is growing 200,000 times faster than world population (Wilson, 2001). Such massive information flows have fundamental implications for societies, with information increasingly embedded in social and physical fabrics, and the rapid emergence of cyber economies and communities. Design practice is increasingly supported by artificial intelligence and integrated information systems, a process which will need ever more urgent development.

Convergence is now occurring at many levels of design – between design technologies (e.g. CAD, rapid prototyping, virtual reality), between process stages (research, development, production, use, disposal), between product technologies (e.g. phones/computers/Internet) and functions (e.g. voice/data/music/video), through design globalization.

Divergence: Divergence creates/evaluates options to determine the evolutionarily fittest, thus accelerating innovation and change. It is especially important in times of high uncertainty, e.g. after the introduction of a radical technology.

Complexification: Biological systems have used complexification as a means of improving environmental adaptation through time. Sociocultural systems have used similar strategies – becoming comprised of more parts, more kinds of parts, and greater integration of these parts – since hunter-gathering (Tainter, 2000:6). Product complexity may arise from the number of product functions and the extent of their interdependence, number of components, novelty of product objectives, and the task uncertainty (gap between what needs to/being known). Process complexity arises from the nature, quantity and magnitude of the organizational tasks, and their interactivity. As time-to-market shrinks, organizational/strategic means of managing this complexity become ever more challenging.

Co-evolution: Strategic alliances between firms emerged particularly from the early 1980s, as a means of gaining market advantage. They offered numerous benefits to participants, including the pooling of resources, complementation of skills, information sharing, joint problem solving, coping with the increasing complexity of products/services. Globalization has greatly increased the use of strategic alliances in new product development.

Turbulence: Design practice is adopting more flexible strategies to accommodate uncertainty and turbulence at many levels (e.g. regulatory, economic, political, environmental, technological).

Creativity: Wallerstein (1999: 250) has observed: ‘We live in an uncertain cosmos, whose single greatest merit is the permanence of this uncertainty, because it is this uncertainty that makes possible creativity – cosmic creativity, and with that of course human creativity’. As humanity moves into increasingly turbulent times, the ability to creatively respond to emerging problems becomes even more crucial. The capacity of humans – designers particularly – to respond accordingly will determine whether global civilisation can chart a successful course. Increasingly, human creativity will be supplemented technologically.

Optimization occurs in various ways, including through miniaturization. Trends will continue towards micromachines and nanomachines, with significant product dematerialization. Such trends will permit closer relationships between humans and their technologies (especially in medicine), improve social equity through lower product costs, permit ‘nomadic’ designing, facilitate embedded environments, hasten cybercities.

Social responsibility of designers should become more comprehensive as their roles become ever more central to societal wellbeing; designers will increasingly need to create products/services consonant with all evolutionary processes of this planet.

5.3 Systemic implications

The above elemental implications are strongly synergistic. While it can be relatively easy to predict elemental futures, their interplay generates surprising futures (emergence). Freeman & Loug(2001:338) talk about constellations of technical and organizational innovations, such as those noted in 5.1 which, as they move through the economic and social system ‘cause profound changes in the structure as well as the occupation and skills profiles and management systems. Moreover, precisely because each constellation is unique, they will have very different effects in each technological revolution’.

6. Design education in the Information Age

Design, it seems, is ultimately about the manipulation of complex adaptive systems. Its industrial age preoccupation with mechanistic systems will recede not only as those systems themselves develop indeterminacy but also as those systems are increasingly viewed as parts of inherently indeterminate larger systems. To the extent that complex adaptive systems are increasingly understood to follow discernible evolutionary pathways, design will become the means by which the conscious evolution of complex adaptive systems, ultimately of socioculture itself, takes place. These propositions suggest an ambitious and exciting agenda for education in the Information Age.

Further layering of design practice: Buchanan’s (1998) four orders of design – communication, construction, strategic planning, systemic integration – describe a progression of design practice of increasing complexity, increasing scale, increasing relevance to core sociocultural concerns. The holistic sciences will see new orders of design codified which further elaborate this progression. Systemicists have long recognized the deeper significance of design to socioculture (e.g. Banathy, 2000); it is timely that the societal role of design be thought afresh by designers also.

Wallerstein (1999: 1) believes that ‘the modern world-system ... has entered into a terminal crisis and is unlikely to exist in fifty years’. If so, the associated transformation will require designerly skills well beyond those of the current design professions! Such developments in design practice should find expression also in design education.

Accessible design education: As designerly approaches become more widely embedded in society, an appropriately reformulated design education should find expression in the learning of other disciplines (e.g. business, politics, science, medicine, law, agriculture) as well as in the general community.

Collaborative design will become ever more important as growing product/process complexity engages more specializations and as end-users become increasingly involved in the design process (mass customization).

Role of virtual worlds: The technologies which create virtual worlds are developing very fast. It seems likely that within a decade or so humans will communicate as effectively in virtual worlds as they do in the real world. This should allow most, perhaps all, of the educational tasks for which face-to-face contact has been considered essential to be performed virtually instead.

Towards pervasive learning: Virtual worlds will become accessible anywhere/anytime/through many devices, making design education possible wherever the learner is in space and time.
Life-long learning: Rapid developments in design practice call for ongoing educational responses. Educational institutions should be more proactive in meeting this emerging need. An “Information Age Bauhaus”: A new model of design education is needed which effectively incorporates the foregoing principles. As with the craft/industrial transition, this will entail a substantive break with the past; it will be revolutionary rather than evolutionary.

7. Conclusions

It remains to consider the when? where? how? of the transition in design education proposed here. Based on the Bauhaus experience, which occurred some 85% of the way through the industrial age, we may expect a model of design education fit for the information age to emerge in 5-10 years. Freeman & Loug[2001:122] recognized 5 semi-autonomous systems in society – science, technology, economy, politics, general culture – following a detailed study of earlier industrial revolutions. It was the interplay of these systems which created circumstances propitious for the various breakthroughs they described, as happened for the Bauhaus and as will happen also for any new educational initiative. The rapidly escalating complexity of design practice at its leading-edge, suggests that an “Information Age Bauhaus” will most likely be a collaborative venture among progressive institutions worldwide.

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MODULAR PRODUCTS AND PRODUCT MODULARITY - IMPLICATIONS FOR THE MANAGEMENT OF INNOVATION AND FOR NEW PRODUCT DEVELOPMENT

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Keywords: Modularity, product architecture, innovation

1. Introduction

“Modular products” have become a hot topic in a number of industries, and particularly in automotive [AW 2001]. For instance, Volkswagen reports that, in its Resende factory in Brazil, it has adopted a modular approach to manufacturing. In this factory, industrial vehicles are made by assembling a limited number of “modules” which are locally pre-assembled by suppliers. A similar approach characterizes the way the Smart city car is made by DaimlerChrysler. In current automotive manufacturing practice it has become customary to use pre-assembled modules for elements such as cockpits (incorporating dashboard, sound system, ventilation pipes and the numerous controls and gadgets that clutter the front area of a car interior), devices associated with vehicle doors (including latches, power windows and loudspeakers) and for bumpers (incorporating headlights and Park distance control). Although the degree with which such approach is economically advantageous is not very clear [Sako and Warburton 1999], it appears that car manufacturers are pushing ahead because they perceive that, by increasing the level of outsourced labor and manufacturing equipment, they may take advantage of suppliers’ cheaper labor costs and, above all, increase their return on assets employed.

From the perspective of the engineering design scholar, this use of the word “modular” seems strikingly inaccurate. Pre-assemblies incorporating heterogeneous functionality and technology seem to negate the essence of “product modularity”, which instead implies functional separation and mutual independence [Ulrich 1995]. This mismatch has not gone unnoticed, and a number of researchers have pointed out that there are different perspectives to modularity [Carnuffo 2001]. While the engineering design literature focuses upon product modularity, which is associated to functional independence, modularity can also be viewed from the perspective of the manufacturing system and that of the structure given to the supply chain.

The relevance of these alternative viewpoints suggests that, in product development, functionality is not the only aspect that should be taken into account when defining product architecture. As a matter of fact, the car industry is clearly using a criterion which is instead related to assembly. As a side note, it should also be noticed that, from the engineering design perspective, the architecture of today’s automobiles is integral and not modular at all. The interlinking among functions and components is very tight, as is the one among performance aspects and components. In other words, there are few components to be found which are individually responsible for a given function or performance indicator. From the perspective of manufacturing, instead, cars seem to lend themselves quite well to a modular architecture with a limited number of large “building blocks” which may facilitate the final assembly process. The following section of this paper will discuss how the product development