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Prospective Ergonomics

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My motivation to write this book on strategic design and prospective ergonomics (PE) has been driven by more than 20 years of experiences as an educator, researcher and design practitioner.

As user needs become increasingly complex, I stress the importance of strategic management for PE and strategic design. Forces of globalization, the proliferation of multicultural societies and emphasis on user experiences have changed the ergonomic, business and design landscape. The concept of “user experience”, with respect to products and services, whether in terms of purely use, ownership or a combination of it, has become a topic of debate among designers, ergonomists, user interaction experts, business management and social science authorities.

Moreover, the significant growth of new technologies has revolutionized the way firms use these technologies both internally and externally to improve operations, increase efficiencies and provide functional benefits for customers. For example, in the service industry, providers and retailers are using a wide range of self-service technologies, including the internet, to allow customers to produce and consume services electronically without direct contact from firm employees [MEU 00]. At present and in the future, these new technologies will continue to challenge the different stakeholders, who are engaged in “innovation”: a process of transforming an idea or invention into a good or service that creates value for customers (www.businessdictionary.com).

However, when adopting a more sustainable and altruistic perspective toward innovation, the discrepancy between technology-driven positivism
and the desired role of technology in society can be perceived as one of the largest paradoxes of our time.

In this book, I attempt to develop a prospective ergonomic framework to structure and connect generic strategies [WHI 01], worldviews and modes of design reasoning. As exemplified in Whittington’s perspectives on strategizing\(^1\), I have been convinced during these years that the main objectives in business and design are broader than just profit maximization and sales. Different stakeholders have diverse ambitions and interests, and designers are creating new roles for themselves in response to new industrial and societal challenges. The current attention on designing experiences, whether tangible or intangible, has placed a significant emphasis on human-centered and design-driven approaches, methods and tools.

Within the polarities of deliberate versus emergent “processes” and targeted versus plural “outcomes”, I am convinced that strong similarities between generic strategies and modes of design reasoning can be identified, which may justify a typical ergonomic or design intervention. For example, a classical approach in strategizing resembles a problem solving approach in designing. Both activities are based upon deliberate processes and outcomes are in terms of management “profit maximization”, whereas in design it is about “solving a design problem”. Furthermore, similarities between design and strategic management/innovation are noticeable in the transient application of methods and tools. For example, visual tools, which are predominantly assistive in projecting an imaginary vision of the future, can be applied in both fields. In other words, the convergence of strategizing perspectives and modes of design reasoning, complemented by their methods and tools brings us to the core of “prospective ergonomics”, which is characterized by its anticipative and imaginary nature [ROB 09].

In this work, I argue for a prospective turn in ergonomics to challenge the established fields of strategic design and management. Differences, similarities and relationships between strategic design and PE are being reviewed using existing theories and frameworks from design, ergonomics, strategic and innovation management. PE has developed from corrective and

\(^1\) Whittington’s generic strategy framework is an important element in my thesis. In conjunction with the evaluation of selected worldviews and models of design reasoning, it provides a foundation for discussing different ergonomic and design interventions. Furthermore, the axial dimensions of Whittington’s framework, which are “Process (deliberate versus emergent)” and “Outcome (Plural versus specific)”, also form the basis for positioning the selected worldviews as well as modes of design reasoning.
preventive ergonomics to be more “forward looking in time” by emphasizing on context, user-experience and human-centeredness. In terms of practice, PE creates awareness among actors that the anticipation of user needs and imagination of radically new products and services are essential for the survival of organizations, their business ecosystems, and formation of societal contexts. The latter encourages PE to adopt stances and reinvent social contexts, which have been impacted by technological advancement and disruptive innovation. Considering the complex constellation of collaborators and context embeddedness in specific design and development projects, PE interventions particularly support innovation activities, which capitalize on deliberate processes by making use of prescriptive methods and tools as well as by aiming for pluralistic results. In the first instance, this book presents several theoretical frameworks to discern the relationship between PE and SD, built upon existing business management and innovation theories. To complement the theoretical part, 12 cases have been organized and analyzed in greater depth according to four main dimensions of analysis. These dimensions were as follows: (1) orientation, (2) type of design reasoning models they were subjected to, (3) their significance for practice, and finally (4) their value contribution to society and stakeholders. Furthermore, cross comparisons were made based upon these dimensions of analysis and reference to how these cases were positioned according to a generic strategy framework. From an educational perspective, results have implicated how design knowledge and skills should be transferred to students. Namely, a hermeneutic, reflective and participatory mode of designing, supported by a constructivist worldview, requires a mentorship and scholarship approach in research- or practice-based learning. In the discussion and conclusion sections, outcomes from individual cases as well as their cross-comparisons have been taken into account by theoretical frameworks in answering five research questions. These outcomes have indicated that innovating through a PE approach is about finding the right balance between, on the one hand, meeting primary objectives, such as profit maximization or solving the design problem, and, on the other hand, achieving social and human well-being, personal interest and ambitions, family relations, etc. Moreover, intervention of PE within a classical strategy perspective requires organizations to couple push–pull market strategies while considering the interest of different stakeholders throughout all stages of the development process. This means that prescriptive approaches, methods and tools in the positivist mode should be complemented with constructive modes of reasoning and designing as well as reflective methods and tools, while taking into consideration all levels and perspectives of value creation.
In future research, I suggest developing sustainable product-service innovation, business and design strategies to become more pluralistic and contextually embedded in nature, whether deliberate or emergent. Involving the participation of a broad network of stakeholders, these strategies are to be applied to selected key areas such as (1) processes, methods and tools, (2) perspectives and mindsets and (3) challenges pertaining to typical focal areas within the context of PE. Identified focal areas are (1) aesthetics and experience design, (2) transportation design, (3) culture, acculturation and interaction design, (4) service design, (5) inclusive design and (6) healthcare and welfare design.

To further elaborate on the above, providing organizations with an understanding of the situated context and dynamic interaction among stakeholders is more important than helping them to positivistically aim for precise, logical and rational innovations and designs. This can be established by creating awareness among researchers, ergonomists and designers that constructivist, reflective and hermeneutic methods and practices are increasingly taking center stage in PE. Moreover, the need for more prominent constructive approaches has been instigated by a change in outlook from different actors in business settings to be more pluralistic oriented, as well as emerging trends and developments in the areas of sustainable product and service design, welfare technologies, corporate social responsibility, etc.

On a personal note, based upon my technical educational background in industrial design engineering (TU Delft), and my current employment at the Norwegian University of Science and Technology, Department of Product Design, I am predominantly approaching and writing this book from a positivistic and structured perspective. However, having frequent interactions with other non-engineering institutions in design teaching and research has guided me to adopt a broader perspective toward designing and design processes, acknowledging and promoting reflective, hermeneutic and participative modes of thinking through more constructivist worldviews.

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In this chapter, a historical introduction as well as an overview of the present and prospective developments of ergonomics will be given. The aim is to provide an outline for approaching theory building within prospective ergonomics (PE), which in Chapters 2 and 3 will be aligned with ancillary fields of strategic design, innovation, systems and industrial design. To contextualize the work, a range of design approaches, such as systems design, design driven and human/user-centered design, will be introduced with respect to different ergonomic perspectives.

Moreover, this chapter sets the tone for developing the construct of prospection and prospective ergonomics by arguing that this new field of ergonomics is driven by a focus on well-being, by being future oriented and design driven and by the fact that product-service innovation, performance and profit should be sought after within systematically embedded contexts. From this perspective of prospection, the intention is to contextually bring the study of preventive and corrective ergonomics closer to the fields of design and strategic management. Consequences are that with the proliferation of services, human–product interactions and sustainable design, where innovation is usually a concern of many stakeholders, the field of preventive ergonomics is extended to PE and design to strategic design. To conclude this introductory chapter as well as initiate the formation and application of theoretical frameworks, it has been brought forward that pluralism toward the creation of new products and services is a typical trait of PE, which enhances company’s competitive advantage.
1.1. History and definition of ergonomics

Ergonomics is the scientific discipline investigating the interaction between humans and artifacts and the design of systems where people participate. It applies systematic methods and knowledge about people to evaluate and approve the interactions between individuals, technology and organizations at work and during leisure. The purpose of design activities is to match systems, jobs, products and environments to the physical and mental abilities and limitations of people [HEL 97]. The aim is to create a working environment (as far as possible) that contributes to achieving healthy, effective and safe operations.

The study of ergonomics (Gr. ergon + nomos) was originally defined and proposed by the Polish scientist Jastrzebowski in 1857, as a scientific discipline with a very broad scope and a comprehensive range of interests and applications, encompassing each human activity, including labor, entertainment, reasoning and dedication [KAR 05]. A historical overview of ergonomics will be presented in the textbox below to make certain events explicit, where business strategies, the design of products and services, and different ergonomic interventions connect. The historical timeline indicates that ergonomics has engaged in systemic ways of strategizing as early as the beginning of 20th Century ergonomics. However, only in the past 25 years has ergonomics gained acceptance among business managers.

According to Perrow [PER 83], the problem of ergonomics is that too few ergonomists work in companies, that they have no control over budgets and people, and that they are seen solely as protectors of workers, rather than creators of products, systems and services. Presently, the value of ergonomics extends beyond occupational health and safety and related legislation. While maintaining health and safety of consumers and workers, ergonomics has become more valuable in supporting company’s business strategies to stay competitive. This has led to the acceptance of the following broader definition of ergonomics:

– ergonomics (or human factors) is a scientific discipline, which aims to develop an understanding about the interaction between humans and other system elements. Furthermore, the profession applies theory, principles, data and design methods to optimize human well-being and overall system performance [IEA 00];

– compared to Jastrzebowski’s definition, the field of ergonomics has become more proactive with respect to problem solving, design, functional
usability and the planning of innovative products and services [ROB 09]. Given this emphasis on ergonomics, the link between business strategies and ergonomics is being established through their common interest in creating and designing improved or new products. Companies are increasingly aware that innovation is essential for maintaining a competitive advantage. As all innovations start with a creative idea [AMA 96], which is both novel and suited to the context of the task [BON 09], it has been acknowledged that end-users of products and services can be important resources for product design and innovation [KRI 02, VON 86]. Within the traditions of preventive ergonomics, user involvement is considered essential for the development of user-friendly product and services, and the participatory design methods and tools that have been developed could be useful for linking ergonomics with product and service innovation.

![Diagram](image)

**Figure 1.1. Interaction among product and service design, business strategies and preventive ergonomics toward prospective ergonomics**

Nowadays ergonomics in industry has the dual purpose of promoting both productivity and “well-being” during and related to working conditions. The continuous search for an optimized balance between productivity and favorable working conditions has given rise to a relatively new type of ergonomics, which is “prospective ergonomics”. The focus of this work is to promote a “prospective turn” to ergonomics as an important feature in strategy formulation and innovation. This means that attention to PE and strategic design can be an important element of how a company realizes its competitive advantage. Figure 1.1 depicts how the interaction between product and service design, business strategies and preventive ergonomics as
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an emergent field of ergonomics, namely PE, could be envisioned. Consequently, PE redefines the ergonomic profession to be more design and business oriented. However, with its original focus on human well-being and anticipation of hidden future needs, the business orientation of PE is pluralistic rather than being purely driven by performance and profit maximization. In practice, this means that the ergonomist must consider the dynamic context of the firm and understand the different strategic objectives of stakeholders [DUL 09].

A historical overview of ergonomics

In the 18th Century, Ramazinni published “The diseases of workers”, where he documented the connection between occupational hazards and different types of work performed. For example, he described how repetitive hand motions, constrained body posture and excessive mental stress caused cumulative trauma disorders.

At the beginning of the industrial revolution, LaMettrie published a controversial piece of work: L’homme Machine (1748), where he outlined that differences in machine and human capabilities are sensitive, and that one can learn much about human behavior by considering how machines operate. For example, the comparison of robots and humans has facilitated our understanding of how industrial tasks should be designed to fit humans better [HEL 95]. According to Rosenbrock [ROS 83], the concept of human-centered design was introduced as early as the industrial revolution through tools, such as spinning machines (spinning mule) used to spin cotton and other fibers. The aim was to allocate interesting tasks to the human operator, but let the machine handle repetitive ones.

The emphasis in ergonomics at the beginning of the 20th Century was largely attributed to Frederick Taylor’s “scientific study of work”. However, his name and work have negative connotations and provoke strong reactions from labor unions and worker’s welfare organizations. In the period round 1900, Taylor examined and scrutinized in what is called the “Taylor system”, how activities were carried out, what movements people made and how much time it took them using time and motion studies. Next, he determined how productivity can be optimized by executing all operations as effectively as possible as in the
minimum amount of time, which resulted in rushed systems, assembly line production, etc.

In the same tradition, Frank and Lillian Gilbreth developed time and motion studies to divide ordinary jobs into several small microelements, called “therbligs” [KON 92]. These objections against Taylorism have resulted in much research to select, classify and train human operators from a well-being rather than productivity perspective. Rejecting the element of exploitation, the current focus is on ergonomics design of environments and artifacts, which means “fitting the task to the person”, not “fitting the person to the task”.

Ergonomics emerged as a scientific discipline in the 1940s because of the growing realization that most people were not able to understand and use the equipment to its full potential and exploits its benefits, as technical equipment became increasingly complex. Focusing on the well-being of workers and manufacturing productivity, the field started to engage in industrial applications in the 1950s and has used information and concepts from work physiology, biomechanics and anthropometry for designing workstations and processes.

As the discipline evolved, variations in terminology emerged in different countries. In the United States, the term human factors took on the same meaning as ergonomics in the UK and continental Europe. Although both terms have been and remain synonymous to professionals, popular usage has somehow nuanced the meaning of the terms. Human factors study the cognitive areas of the discipline (perception, memory, etc.), whereas ergonomics specifically deals with physical aspects, such as workplace layout, light, heat, noise, etc. This is exemplified by how the terms human factors engineering, human factors and engineering psychology has proliferated in the United States military sector after WWII, where high demands were placed on the physical and cognitive demands of the human operator. Many military design problems were encountered in the use of sophisticated war equipment, such as airplanes, radar and sonar stations, and tanks. For example, during the WWII, with the increasing number of pilots and technological complexity of airplanes, it was discovered that cockpits were not adequately and logically organized and designed, causing fatal accidents to occur.
In Europe, technological achievements of WWII and post-WWII were quickly transferred to civilian applications, including the design of consumer products such as cars and computers. Here, similar problems of disharmony between people and equipment were encountered. This resulted in poor user performance and an increased risk of human error. Particularly in Germany, The Netherlands and across Scandinavia the foundation for ergonomics was developed out of medical and functional anatomy studies, while in Eastern Europe growth was largely from the industrial engineering profession [SIN 94].

Thereafter, the Ergonomics Research Society (ERS), which was founded in 1949 from a theoretical and research perspective, has evolved to represent the current discipline, both in the United Kingdom and internationally. In 1977, the ERS was renamed the Ergonomics Society (ES), because of an increased focus on the professional practice and application of ergonomics. The ES became the first professionally registered body and Charity in the field of ergonomics. It also gained the status of a Company limited by guarantee in 1985.

1.2. Classification and positioning of ergonomics

Over the past 50 years, ergonomics has evolved as a unique and independent discipline that focuses on the nature of human–artifact interactions, and made connections with engineering, design, technology and management from a science perspective. Within a systemic human–artifact relationship, a variety of natural and artificial products, processes and living environments are emphasized [KAR 05].

The analysis of poor performance, human errors and accidents due to difficulties faced by the human operator when interacting with objects in specific contexts provided a growing body of evidence to facilitate the understanding of man–machine systems (now human–machine systems) and interactions. This stimulated research by the ergonomic academic and military community which led to further investigations of the interactions between people, equipment and their environments. Accordingly, this has resulted in a substantial body of documented knowledge, methodologies and skills for analyzing and designing interactive systems between humans and their environment [DUL 12]. When defining ergonomics from a practice perspective, ergonomic practitioners continue to improve tasks, jobs, products, technologies, processes, organizations, environments and systems