IDEAS

1. Design Methodology in University ScienceTechnology and Society (STS) Programs

by Marc J. de Vries

WHAT IS DESIGN METHODOLOGY?

Design is a core activity in technology. It is not possible to communicate what technology is without mentioning design. Design integrates phenomena of the natural sciences, technological tools and methods, and social demands and constraints. Analyses in design methodology show how scientific, technological, and social factors interact in the creation of new products and processes. If we accept Bochenski's (1965) view that methodology is the theory of the application of the laws of logic to various fields, then design methodology is the study of how a logical use of different types of knowledge takes place or can take place. Although rather narrow, this definition emphasizes that methodology is not only the study of methods in the sense of prescriptive step models.

Design methodology as an academic discipline is only about 30 years old. At first, design methodology was concerned with producing prescriptive representations of design processes, usually based on the two premises that:

1. the description of the design process is independent of the technology or product type that is involved, and
2. the design process includes (a) analysis of the problem, (b) synthesis of possible solutions, and (c) evaluation of the design proposal.

Both premises were challenged by research which showed that there are significant differences between the design of different types of products and that designers, throughout the design process, engage in analysis and also synthesis and evaluation activities. It also became clear that prescriptive design process models can have a negative influence on the design process. That is to say, they tend to become so autonomous that relationships of changing scientific, technological, and social contexts are forgotten because all effort is put into "blindly" following the steps in the process.

Today two "cultures" of research in design methodology still exist (de Vries, 1993). One culture focuses on the "internal" design process and does not consider social factors. It usually includes four groups:

1. Practitioners, particularly from construction engineering and mechanical engineering, who represent the design process with flow charts and step models;
2. Cognitive psychologists, who study the way designers think;
3. Experts in business management, who develop methods for relating design to elements such as production, logistics, and marketing; and
4. Computer experts, who work on software that supports design activities.

The other culture focuses on the scientific and social context in which design activities take place and, in particular, the various scientific and social factors that influence design. Here we find historians, who study the way designs have evolved during different historical epochs and among different settings; philosophers, who study the nature of the knowledge that is involved in design; natural scientists, who study science-design relationships; and sociologists, who focus on the social factors that influence the design.

It is in the second culture that we find the science-technology and technology-society relationships which are the key issues in STS programs. This culture, which is the focus of this article, is often known by its broader name *technology dynamics*. Vincenti (1990) characterized the types of knowledge that designers use and the way these types of knowledge are developed. This belongs to the field of design methodology (more specifically, design epistemology), but was not qualified as such explicitly. Usually the term *design methodology* is equated with the first culture. However, the meaning of the term *methodology* according to Bochenski (1965) does not support his equation.

TYPES OF STS PROGRAMS

In this article, two types of academic programs in which scientific-technological and social knowledge are brought together are distinguished.

1. Engineering based programs that educate engineers with a thorough basis of engineering know-how and some knowledge of the social circumstances under which technological developments take place. The purpose is to provide knowledge of social needs and constraints as they develop new technologies.
2. Social science based programs that educate social scientists with a special focus on technological developments.

Programs of the first type are usually concerned with the development of new technologies that must consider social factors. Engineers trained in such programs use insights of scientific-technological and social factors to make design decisions. Programs of the second type deal more with the consequences of implementation and diffusion of new technologies in society. Here an understanding of the technology itself is necessary to understand the way it is implemented in certain parts of society. The roles of various actors in this process are also considered.

Some programs have a hybrid character. For example, the Technology and Society program of the Eindhoven University of Technology trains engineers who can contribute to policy making related to technological developments. These engineers do not develop new technologies themselves, but carry out research that supports technology policy making.

The first type, the engineering based STS programs, yield opportunities for integrating design methodological studies into the program. Here design methodology could play the role that technology assessment plays in the second type of STS programs that are social science based. In a way, design methodology and technology assessment are analogous: Both are aimed at integrating scientific-technological and social know-how for decision making about technological developments. The difference is that design methodology supports decision making for development of the technology, and technology assessment supports decision making for the implementation of the technology. The boundary becomes blurred when technology assessment moves into the direction of technology assessment, in which impact analyses are used to influence the way the technology is developed (Smits, Leyten, & Geurts, 1987).

Design methodology can also be regarded as complementary to theories in technology dynamics, such as social constructivism, that focus on social actors while design methodology focuses on factors or phenomena (natural and social).

STATUS OF DESIGN METHODOLOGY IN STS PROGRAMS

Design methodology does not seem to play a vital role in most STS programs. Surprisingly, this holds for both categories of STS programs described above. One would expect that in the engineering based STS programs, design methodology would already be present. The lack of design methodology in STS programs could be the difficulty in making real integration of scientific-technological and social know-how. Since most programs are currently multidisciplinary, having several separate disciplines represented, there are difficulties in achieving integration. Because design methodology is aimed at making this integration, it could make a relevant contribution to STS programs.

These remarks are based on this reporter's review of a number of different STS programs worldwide. This included Mitcham's survey of STS programs in the United States (Fricke, 1992) and information derived from descriptions in promotion brochures.

Generally, it should be kept in mind that when the phrase *design methodology* is not mentioned, that does not mean that the concept is not there. But even if it is represented, the manner by which social factors are integrated in product design in both engineering or social studies based programs is not explicit.

ONE WAY TO DO IT

The Eindhoven University of Technology (EUT) teaches STS programs. Design methodology is taught in a compulsory course, Design Methodology for STS, and two electives, Special Topics in Design Methodology and Environmental Issues in Design Methodology. In the compulsory course:

1. students are acquainted with the basic concepts of experience-based technologies, macrotechnologies and microtechnologies, and the concept of multifactorial design methodological analyses;
2. these concepts are illustrated by case studies: bridge design, the Brabantia corkscrew (de Vries, 1994), the Philips Stirling engine (de Vries, 1993), and the Philips Plubicon (Salemijn & de Vries in Kroes & Bakker, 1992); and
3. a brief survey of other approaches in design methodology is given.

As an extension of the preceding course, special topics in Design Methodology explore the various approaches in design methodology in more detail and additional case studies are discussed to illustrate the idea of multifactorial analyses in design methodology.

The second elective course focuses on design for sustainability and includes case studies of multifactorial analyses to show their relevance for green design (e.g., Stirling refrigerating equipment, the three-way catalyst) and new developments in methods for green design (e.g., life cycle analyses, relationships among the design variables of form, material, and treatment). These methods are illustrated with case studies that have been reported in some Dutch projects.

The content of design methodology education at Eindhoven was selected to fit the general goal of educating engineers who are able to integrate technological and social factors into the decision- and policy-making process for developing and/or implementing technology. Toward the end of their studies at Eindhoven, students engage in case studies in an industrial setting. Much of the success they have achieved in these real situations can be attributed to their design methodology abilities and techniques.

DISCUSSIONS ON THE FUTURE OF THE EUT STS PROGRAM

The success of such studies does not mean there are no problems. In fact, the EUT STS program faces the same problems that Cheek (1993) identified for STS programs for both primary and secondary education:

1. Opposition from the traditional programs (in this case the engineering programs),
2. Staffing (finding faculty members who combine a technological and a social science background), and
3. Multidisciplinarity (making a real integration of technological and social know-how).

References

Bochenski, J. M. (1965). *The methods of contemporary thought.* Dordrecht, Netherlands: Reidel.

Cheek, D. W. (1993). *Thinking constructively about science, technology and society education. A*lbany: State University of New York Press.

de Vries, M. J., Cross, N., & Grant, D. P. (Eds.) (1993). *Design methodology and relationships with science.* Dordrecht, Netherlands: Kluwer Academic Publishers.

de Vries, M. J. (1993). The Philips Stirling engine development: A historical-methodological case study into design process dynamics. *Methodology and Science, 26*(2), 74–86.

de Vries, M. J. (1994). Design process dynamics in an experience based context: A design methodological analysis of the Brabantia corkscrew development.*Technovation, 14*(6).

Fricke, E. (Ed.). (1992). *Interdisziplinäre Technikforschung und Ingenieurausbildung.* Bonn, Germany: Friedrich Ebert Stiftung.

Sarlemijn, A., & de Vries, M. J. (1992). The piecemeal rationality of application-oriented research: An analysis of the R&D

history leading to the invention of the Philips Plumbicon in the Philips Research Laboratories. In P. A. & M. Bakker, Kroes *Technological development and science in the industrial age.* Dordrecht, Netherlands: Kluwer Academic Publichers.
Smits, R. E. H. M., Leyten, A. J. M., & Geurts, J. L. A. (1987). *Technology assessment: An opportunity for Europe* (Vol. 1). The Hague, Netherlands: Staatsuitgeverij.
Vincenti, W. G. (1990). *What engineers know and how they know it.* Baltimore, MD: John Hopkins University Press.

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Details on the Eindhoven programs as well as the universities that were surveyed can be obtained by writing or emailing the author.

2. Simulation in Employee Training Achieves Risk Management

by Phillip S. Waldrop

"The importance of overcoming basic ignorance and fear and developing a common understanding of capabilities, limitations, and implications is critical to quelling worker and management fears" (Giffi, Roth, & Sean, 1990, p. 321).

To better establish the context for the simulation and its importance, a brief review of the factors leading to changes in production, some specific changes, and the change effects upon workers are discussed. Presented here is a case study of how the top management of one small company sought to communicate with its employees. The goal was to demonstrate effectively with a hands-on instructional technique the problems and limitations inherent in the traditional approach to manufacturing, in contrast with the merits of other new approaches, which tend to create some turmoil during their adaptation and implementation in the firm. The instructional technique described here is available to other firms and for use in academic programs in which technology and management professionals are prepared. The simulation effectively, clearly, and meaningfully teaches the ideas and benefits underlying the new approaches.

FACTORS LEADING TO CHANGE

In recent years much of the published material has focused on the benefits of methods and techniques that are often lumped under the category of "World Class Manufacturing." These imply that to survive in a very competitive global economy, companies must effect improvements in key areas of cost, quality, and scheduling. Two common approaches that address these key areas are cellular production organization cells with teams and just-in-time (JIT) production operation.

Such approaches are "buzzwords" in today's literature, the meanings of which are fairly well understood by those who have studied them. They are likely to be less understood by many who are impacted by them in their workplace. The changes suggested by the buzzwords involve breaking away from traditional and familiar methods that have provided the fabric of the company's internal "culture." Very large and prominent industries have often led the way in application and implementation of such approaches because they have the depth of resources to plan, invest, and manage such major changes. Yet the vast majority of manufacturers in and beyond the United States are small companies that may face proportionately greater risk if their efforts to effect change do not succeed. A 1994 survey of advanced manufacturing efforts, conducted by the Computer and Automated Systems Association of SME, found that 75% had failed, and that efforts to re-engineer business processes failed 80% of the time (Owen, 1996). A critical element of risk is "user acceptance" of new methods and tools: members of the workforce must understand and accept the goals, objectives, and potential benefits of what is likely to be a major change in their working environment and jobs. Acceptance of change may be particularly important as team concepts such as empowerment in decision making are introduced.

COMPETITIVE DEMANDS, CELLS, AND JIT

Cells and JIT are related to what may be called time-based competition. In the past, competitive emphasis was on low price; after World War II, the Japanese, seeking economic recovery, first entered the U.S. market with low-priced goods. Under the influence of such persons as J. Edwards Deming, there were shifts toward higher quality, a competitive thrust which is still a significant area of study and influence on change for competitive survival (Deming, 1986; Hayes, Wheelwright, & Clark, 1988). Industry constantly strives for lower internal costs in order to meet market price demands, and product quality has generally improved and continues to be refined in all types of products.

Today, far more sophisticated consumers expect both good price and quality. While still striving for continuous improvement of cost and quality, industry now faces major competitive pressure in regard to time-to-market. From product concept to presence on the store shelf or showroom floor, product development and production timelines are shrinking (Wantuck, 1989). Firms that fail to get new products into the consumers' view quickly will typically lose significant market share to their competitors (Steudel & Desruelle, 1992). Product competition today also involves pursuit of consumers through introduction of new products and offerings of many variations to match the varied preferences of a diverse consumer base.

Such dynamics have negated much of the old economy-of-scale basis for production operations, and flexibility is now a key driver. Methods such as concurrent engineering help to reduce the design timespan, while in the production area cellular organization of the factory and JIT processing seek to get the product built and out the door (Giffi et al., 1990).