2001

Janus: the multiple faces of engineering design

Ross D. Wotherspoon
University of Wollongong

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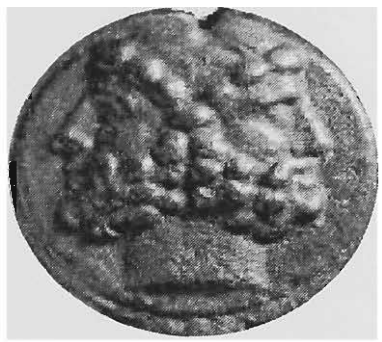

The Multiple Faces of Engineering Design

A Thesis Submitted in fulfilment of the requirements for the award of the degree

PhD

From

UNIVERSITY OF WOLLONGONG

By

Ross Wotherspoon
BE Mech (Hons), MBA (Merit)

Department of Management

2001

CERTIFICATION

I, Ross D. Wotherspoon, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Department of Management, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Ross D. Wotherspoon

5 September 2001

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List of Abbreviations

5MTPA	Five Million Tonne Per Annum
BHP Pty Ltd	Broken Hill Propriety Limited Company
BHP	Broken Hill Propriety Limited Company – Steelworks Port Kembla
BOS	Basic Oxygen Steelmaking
LK	Lime Kiln
PLC	Programmable Logic Controller
WTP	Water Treatment Plant

Abstract

This study is a sociological exploration of the work of engineering design. The data for this research were generated from a two-year ethnographic study of three engineering design projects within an Australian iron and steel producing company. This study provides an account of the activities undertaken, by engineers and others, during the design of human computer interfaces for process control.

The study takes a symbolic interactionist perspective and acknowledges its criticisms. The study draws on Strauss's social worlds/arena theory, and Clarke's subsequent conceptualisation of the theory in an organisational context, to provide a broad set of sensitising concepts focussed on the interactive aspects of the construction of meaning amongst the social collectives involved in the process of engineering design.

The findings of this study are organised around five interlinked and over lapping themes – *trajectories of technology and work, design boundaries, engineering and operator social worlds, arenas in the process of design,* and *routine and non routine action.* These themes reflect emergent concepts identified through the constant interplay between observation and analysis.

The accounts given describe design negotiations riven through with ideologies of engineers, plant operators, and others, as individuals and as members of social collectives, such as occupational groups. I have come to understand these negotiations can be seen as battlefields with winners, losers, and only sometimes agreeable truces.

These battles are conducted according to what appear to be predetermined rules of engagement that reflect - and define - who has power and over what elements of the battle that power can be exercised. The outcomes of these battles are design specifications that guide the 'trajectory' of a technology from an initial concept toward its final shape.

This study is intended to provide a needed addition to the literature - detail on how individuals and groups go about creating new technological artefacts in an industrial design context. My hope is to assist both academics and practitioners in improving the process of engineering design.

Acknowledgments

This study has been made possible through the collaborative efforts of the workers and management of BHP Steel, the BHP Institute for Steel Processing and Products (ISPP), the University of Wollongong Department of Management, and the Australian Research Council.

The BHP ISPP was established in 1995 and consolidated a long history of collaboration between the University of Wollongong and BHP Steel. The institute is multi-disciplinary and concentrates on focussed academic research. The institute derives much of its project funding from competitive government funding schemes, creating a triangular alliance between government, industry, and university.

This study has been conducted under the auspices of ISPP 'Management of Innovation and Organisation Change' Program. This program is typified by in depth, long term ethnographic and action research studies that aim to contribute to academic research on innovation, technological change, and organisational learning.

Throughout the course of this study I have had the pleasure of the supportive assistance of three wonderful supervisors - Richard Badham, Karin Garrety, and Will Rifkin. They have each freely given their time and knowledge, greeting every one of my new ideas, directions, and tangents with genuine enthusiasm and rigorous academic debate. The final form of this dissertation is a testament to their combined input and guidance.

Special thanks go to Richard Badham for initially creating the industry and academic opportunities for this research to take place.

Finally, I am most indebted to my lovely wife Catherine and our two beautiful daughters, Jessica and Emily, whose gracious love, support, and sacrifice has made this dissertation possible.

Preface

Prior to embarking on this study I had spent twelve years working as an engineer in the Australian iron and steel industry. I performed many roles during this period, starting as an engineering cadet and then moving through the professional ranks into management positions. These roles required the performance of a variety of tasks, including technology design, project management, technology support, technology maintenance, and technology operation.

Many of the engineers whom I met during this period spoke at one time or another of their dreams of a 'technological utopia'. In these dreams, they envisaged industrial plants where the tasks of operators were usurped by the marvels of technology. The foibles and frailties of the human race were forgotten in the blaze of precision machine measurement, movement, and reasoning. Unfortunately for most of these engineers, when they awoke from their dreams, they faced a reality far removed from their utopia - a reality where machines broke down, technology failed, and in the end, human operators remained to pick up the pieces.

The idea for this study was born from my observations of one such engineer's search for his small slice of technological utopia. His particular quest involved the replacement of a manual, paper-based, warehouse inventory management system with hand-held computers, bar codes and readers, and radio frequency data links to a mainframe computer system. His quest was conceived at a trade-show where his eyes were drawn to the latest hand-held computer terminal, the Janus 2010, developed by Intermec.

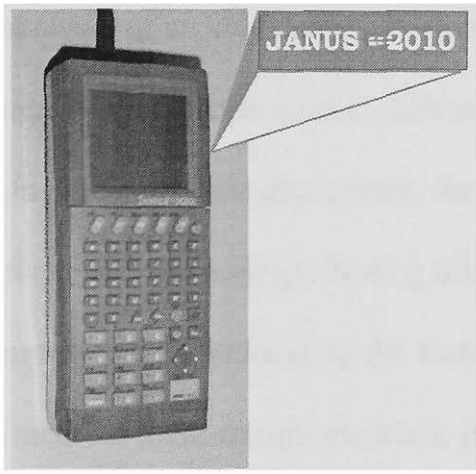
Unfortunately, for the engineer in question, the reality he faced upon awaking from his project was one where the Janus technology remained locked in the cupboards of the operators, untouched and lifeless. The paper-based system endured and does so to this day. Although the technology performed within the requirements of the engineer's specifications, he was unable to overcome what seemed to be well founded and well managed operator resistance.

The ageing, predominantly migrant, workers were unable to read the small liquid crystal displays on the hand-held terminals whilst operating them in the dimly lit warehouse. Nor were they able to understand the complex training sessions. Further to this, these workers had for many years performed manual labour tasks in the plant. As a result, their large callused fingers were unable to accurately press the small keypad buttons. In addition, the workers appeared to perceive the Janus project as a threat to their continued employment due to an ongoing distrust between workers and the management.

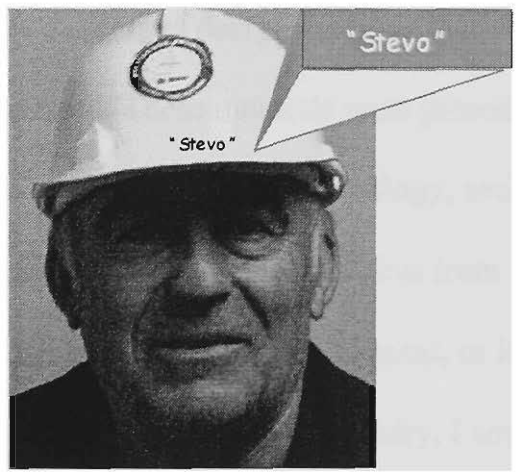
Under the combined weight of these factors, the workers instigated what appeared to be a well organised campaign of overt and covert resistance. One of their more ingenious covert schemes involved the gradual removal of the bar code labels from the products. Inch-by-inch, day-by-day, the workers would secretly peel the edges of labels from the product. This ongoing process appeared to the engineer as an incompatibility between the adhesive and the product surface. For more then six months, specialist label consultants from 3M endeavoured to select an adhesive that would successfully bond the label to the product. Eventually, a shipment of products was dispatched directly to China with test labels attached. After two weeks in transit, and four weeks in a Chinese

warehouse, it was reported that all labels remained completely intact. This result alerted the engineer to the covert scheme of label removal, though no punitive actions were ever taken.

Intermec's decision to name their hand held computer 'Janus' was perhaps more apt for this project than they might have imagined. Janus is the mythical Roman God of gates and doors, depicted with two faces looking in opposite directions. To the chagrin of the instigating engineer, the Janus project had a technological face and a social face, both of which required his equal consideration.



A Technological Face



A Social Face[1]

There is a multiplicity to these two faces of the Janus Project. The technological face can be seen as including the Janus 2010 hand held computer, bar code labels, bar code readers, systems of radio frequency links, mainframe computer system, and software, to name but a few. Likewise, the social face can be considered to include Stevo, the

[1] This photo and all other forms of collected field data presented in this dissertation have been done so with written permission of the human subjects involved.

engineer, and every other actor involved in the process of design and implementation, both overt and covert, and the social collectives that they may represent. Further to this, the technological faces are a reflection of the social processes through which they were created. In turn, these social processes are a reflection of the participants', as both individuals and representatives of their social collectives, interpretation of technological, social, cultural, political, and economic circumstances within which the Janus project was undertaken.

My goal when I first conceived of this study was to develop a design method that encompassed the multiple faces of engineering design. In pursuing this goal, I quickly became aware of an abundance of previously developed design methods that were purported by their proponents to address this need. These methods were presented in a wide range of academic disciplines, for example, engineering, psychology, sociology, and information technology. Noting this proliferation, I shifted my focus from 'methods development' to understanding the factors that influenced the deployment, or lack of deployment, of these design methods. In following this avenue of inquiry, I sought out studies that depicted the social processes of engineering design in the hope that they might illuminate relevant factors worth studying. This inquiry highlighted for me the dearth of literature describing in detail the social process of design. This 'gap' inspired the final focus of this study - the development of an understanding of the actions of humans engaged in the process of engineering design.