

**AN APPROACH FOR THE DEVELOPMENT OF COMPUTER BASED BEST
PRACTICE DELIVERY MECHANISMS FOR SMALL AND MEDIUM SIZED
MANUFACTURING ENTERPRISES**

by

PHILIP ANDREW SMART

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Computing
Faculty of Technology

October 1996

An approach for the development of computer based best practice delivery mechanisms for small and medium sized manufacturing enterprises

Philip Andrew Smart

October 1996

Abstract

Changes in the competitive environment have strongly influenced manufacturing companies to adopt and develop best practice. Best practice is usually imported into companies using the services of consultancy organisations. The use of consultancy services does not guarantee success however, and inadequate results have been obtained by practitioners who have engaged in client-consultant relationships. The inadequacy of these results may be explained by the installation of pre-defined solutions by consultants as opposed to the adaptation and implementation of solutions to meet the specific requirements of practitioners. This may in part be explained by a lack of understanding of 'best practice'.

This work presented in this thesis investigated the feasibility of computer based mechanisms for intervention in small and medium sized enterprises (SMEs) for the delivery of best practice. The research was undertaken using a prototyping approach. Three prototype computer based tools (CBTs) were developed by the author and tested by practitioners. The prototypes were designed based on a set of objectives and a framework of features which was developed. These frameworks were constructed from a synthesis of the research findings which included a study of best practice, the identification of characteristics of types of intervention, the identification of SME characteristics, and inhibitors of change in SMEs.

The research has indicated that an approach using computer based tools is appropriate for intervention in SMEs and for adapting best practice to meet specific requirements. A structured project management approach is required with identifiable goals and benefits. An exploratory learning environment should be used to deliver complex best practice concepts and to support the goal oriented approach. Tools and techniques provided by the CBT enable the achievement of methodological tasks and facilitate experimentation and learning. The approach should not prescribe solutions, but should provide information through computer generated analyses to support decision making. The research suggests that the proposed approach may support a workbook based methodology, or may encapsulate a process methodology.

The originality of this work is in the provision of a definition of best practice, an explanation of the deficiencies of existing mechanisms for the transfer of best practice to SMEs, and the specification of the features required by a new computer-based approach. This provides new knowledge for the field of production and operations management.

CONTENTS

<u>CHAPTER ONE - Introduction</u>	1
1.1 Background	1
1.2 Previous research	3
1.3 Aims of the research	3
1.4 Contribution of the research	4
1.5 Structure of the thesis	5
1.6 Summary	8
<u>CHAPTER TWO - Research method</u>	9
2.0 Introduction	9
2.1 Identification of research domain	10
2.2 The research cycle	10
2.2.1 Description	11
2.2.2 Explanation	12
2.2.3 Testing	13
2.2.4 Exclusion of research phases	14
2.3 Research relevance	14
2.3.1 Descriptive relevance	14
2.3.2 Goal relevance	15
2.3.3 Operational validity	15
2.3.4 Non-obviousness	16
2.3.5 Timeliness	16
2.3.6 Summary of research relevance	16
2.4 Research strategy	16
2.5 Literature survey	17
2.6 Prototyping	18
2.7 Synthesis - the research approach	20
<u>CHAPTER THREE - Best practice in manufacturing</u>	23
3.0 Introduction	23
3.1 The need for best practice	23
3.2 What is best practice in manufacturing?	25
3.2.1 World Class Manufacturing	26

3.2.1.1 Principles of World Class Manufacturing	26
3.2.1.2 Practical implementation of World Class Manufacturing	27
3.2.1.3 Identified issues	28
3.2.2 Lean Production	29
3.2.2.1 Principles of Lean Production	29
3.2.2.2 Fit to the environment	31
3.2.2.3 Identified issues	32
3.2.3 The role of information technology	32
3.2.3.1 Information technology as best practice	32
3.2.3.2 Identified issues	33
3.2.4 Application of best practice	33
3.2.4.1 Take-up of best practice by industry	33
3.2.4.2 Explanation of poor take-up	34
3.3 Conclusion	36
<u>CHAPTER FOUR - Modes of intervention and existing delivery mechanisms</u>	38
4.0 Introduction	38
4.1 Consultation	38
4.1.1 Acceptance interventions	41
4.1.2 Catalytic interventions	42
4.1.3 Confrontative interventions	43
4.1.4 Prescriptive interventions	43
4.1.5 Theories and Principles interventions	44
4.2 Process consultation	45
4.3 Workbooks	47
4.4 Methodologies	49
4.5 Conclusion	52
<u>CHAPTER FIVE - Characteristics of small and medium enterprises</u>	54
5.0 Introduction	54
5.1 Characteristics of small and medium sized enterprises	55
5.1.1 General characteristics	56
5.1.2 Technological characteristics	57
5.2 Consultancy and small and medium sized enterprises	59
5.2.1 Consultant characteristics	59

5.2.2 Engagement	60
5.2.3 Identified problems	61
5.3 Inhibitors for change within small and medium sized enterprises	62
5.3.1 Research method	62
5.3.2 Inter-group trends	63
5.3.2.1 Knowledge sharing	63
5.3.2.2 Skills and education	63
5.3.2.3 Information technology	64
5.3.3 Group specific issues	64
5.3.3.1 Owner group	64
5.3.3.2 Transition to emergent functional group	65
5.3.3.3 Functional group	66
5.3.4 Workshop conclusions	67
5.4 Conclusion	68
<u>CHAPTER SIX - Objectives and features of prototype computer based tools</u>	70
6.0 Introduction	70
6.1 Selection of methodological approaches	70
6.2 Objectives for computer based tools	71
6.2.1 Knowledge transfer	71
6.2.2 Low cost	72
6.2.3 Availability of time	73
6.2.4 Deficiencies of existing mechanisms	73
6.2.5 Management development	74
6.3 Summary of computer based tool objectives	75
6.4 Features of computer based tools	75
6.4.1 Role of the computer based tool	76
6.4.2 Structure and guidance	76
6.4.3 Tools and techniques	77
6.4.4 Decision formulation or decision support	78
6.4.5 Project management	79
6.4.6 Group working	79
6.4.7 User interface	80
6.4.8 Data entry	82
6.5 Conclusion	82

<u>CHAPTER SEVEN - Prototype one: STRATAGEM</u>	86
7.0 Introduction	86
7.1 Selection of best practice	86
7.2 Background	87
7.2.1 Methodology background	88
7.2.1.1 Methodological structure	88
7.2.1.2 Operation of the process	92
7.3 Approach for the automation of the methodology	93
7.3.1 Background research	93
7.3.2 Prototype development	94
7.3.2.1 Role of the computer based tool	94
7.3.2.2 Integration with off-line activities	95
7.3.2.3 User interface	97
7.3.2.4 Supply of supporting documentation	100
7.3.2.5 Entry and storage of information	101
7.3.2.6 Analyses	102
7.3.2.7 Project management	104
7.3.2.8 Quick tour	105
7.3.3 Summary of prototype features	106
7.4 Prototype tests	107
7.4.1 Company A	107
7.4.2 Company B	109
7.5 Conclusion	111
<u>CHAPTER EIGHT - Prototype two: PROFIT</u>	113
8.0 Introduction	113
8.1 Methodology background	114
8.1.1 Methodology structure	115
8.1.2 Operation of the process	116
8.2 Approach for the support of the methodology	117
8.2.1 Role of the computer based tool	117
8.2.2 Interface	118
8.2.3 Data entry	119
8.2.4 Tools and techniques	121

8.2.5 Decision formulation and decision support	127
8.2.6 Project management	127
8.2.7 Group working	127
8.2.8 Summary of features	128
8.3 Prototype tests	129
8.3.1 Company C	130
8.3.2 Company D	130
8.3.3 Evaluation results	131
8.4 Conclusion	133
<u>CHAPTER NINE -Computer based knowledge transfer</u>	135
9.0 Introduction	135
9.1 Context	136
9.1.1 Learning focus	136
9.1.2 Deficiencies of technology based solutions	137
9.2 Models of learning	138
9.3 Instructional design	139
9.3.1 Orientation	140
9.3.2 Presentation	141
9.3.2.1 The design of stimuli	141
9.3.2.2 Combination of media - the potential of technology	141
9.3.2.3 Structure of appropriate stimuli	142
9.3.3 Sequence	144
9.3.3.1 Learner interaction	145
9.3.3.2 Access structure	146
9.3.4 Encoding	147
9.3.5 Retrieval	148
9.4 Issues for consideration	148
<u>CHAPTER TEN - Prototype three: exploratory learning environment</u>	151
10.0 Introduction	151
10.1 Business Process Re-engineering	152
10.2 Approach for prototype development	154
10.2.1 Information architecture development for Business Process Re-engineering	154

10.2.2 Computer based tool design	158
10.2.2.1 Background research	158
10.2.2.2 User interface	160
10.2.2.3 Implementation of node and link architecture	161
10.2.2.4 Previewing information	162
10.2.2.5 Media usage	163
10.3 Practitioner evaluation	165
10.3.1 Stage one evaluation	165
10.3.2 Stage two evaluation	167
10.4 Conclusion	168
<u>CHAPTER ELEVEN - Conclusions</u>	171
11.0 Introduction	171
11.1 The research methodology	172
11.2 Research problem	173
11.3 Results of literature survey	174
11.4 Objectives and features of computer-based approaches	176
11.5 Required approach for computer-based tool interventions	181
11.6 Contribution of the research	181
11.7 Future research	183
<u>References</u>	184
<u>Appendix 1 - Responses from SME workshop</u>	
<u>Appendix 2 - Additional projects</u>	
<u>Appendix 3 - Conceptual model of the synthesis of prototypes</u>	
<u>Publications</u>	

List of tables and illustrations

Fig. 1.1 The prototyping cycle	19
Fig. 1.2 Research method model	20
Table 3.1 Principles of World Class Manufacturing	27
Table 3.2 Principles of Lean Production	30
Fig. 4.1 Roles of consultants	40
Fig. 7.1 Detailed steps of methodology structure	90
Fig. 7.2 Integration of on-line and off-line activities	96
Fig. 7.3 Interface layout design features	98
Fig. 7.4 Access mechanisms to methodology task detail	100
Fig. 7.5 On-line proforma	101
Fig. 7.6 Example dialogue	102
Fig. 7.7 Computer generated analysis	103
Table 7.1 Summary of features for prototype one	106
Table 7.2 Evaluation results from Company A	108
Table 7.3 Evaluation results from Company B	110
Fig. 8.1 Interface design features	119
Fig. 8.2 Example of data entry process	120
Fig. 8.3 Projection of operating variables	122
Fig. 8.4 Results of projection	122
Fig. 8.5 Business need selection	123
Fig. 8.6 Selection of target area for change	124
Fig. 8.7 Selection of technology	125
Fig. 8.8 Benefits of technology implementation	126
Table 8.1 Prototype two evaluation results	128
Fig. 9.1 Framework for linking items of information	144
Fig. 10.1 Fundamental issues for Business Process Re-engineering	153
Fig. 10.2 Hypermedia node and link structure	155
Fig. 10.3 Composite architecture	157
Fig. 10.4 Internal and external links	158
Fig. 10.5 Dynamic animation of a business process	159
Fig. 10.6 User interface layout	160
Fig. 10.7 Access mechanism for navigation	161
Fig. 10.8 Preview mechanism	163

Fig. 10.9 Instructional sequence of standard process models 164

Fig. 10.10 Interactive component of standard process model sequence 165

Acknowledgements

During the period of this research I have been supported and encouraged by many individuals. While I am unable to thank everyone by name, I am grateful to all who have helped and supported me.

I would like to thank my wife Jo, and children, Benjamin and Ioan for their understanding and support. I would also like to thank my supervisory team, Professor David Hughes, Dr Stephen Childe and Dr Jan Bennett. Without their supervision and guidance this thesis would not have been possible. I must also thank all of the members of the Manufacturing And Business Systems (MABS) research group at the University of Plymouth, especially an ex-colleague Dr Adam Weaver.

The work was supported by facilities provided by Professor Patricia Pearce, Head of the School of Computing, University of Plymouth, and funds provided by the Engineering and Physical Sciences Research Council.

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

The research has been undertaken while the author has been employed at the University of Plymouth on two externally funded projects. In both cases the funding was supplied by the Engineering and Physical Sciences Research Council (EPSRC). The initial funding was for the research project reported in this thesis and was provided as a studentship. In the second project the author was a member of a research team and was involved with activities associated with research grant (GR/J95010) which was supported by British Aerospace (Systems and Equipment) Ltd.

Although the author has worked as part of a team during the period of the research, the research described in this thesis were the results of work undertaken by the author.

The publications that have been produced during the research are presented at the end of the thesis. These include:

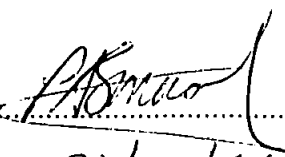
Smart, P A, Hughes, D R, The use of computer based best practice delivery mechanisms in education, Computer Assisted and Open Access Education, XXIX Annual International Conference of the Association for Educational and Training Technology, Edinburgh, April, 1994.

Hughes, D R, Smart, P A, White S, Benchmarking manufacturing performance - the results of the UK manufacturing survey 1993, in Platts K W, Gregory M J, Neely A D, (Eds.) Operations Strategy and Performance, Papers from the International Conference of the European Operations Management Association, Cambridge, 27-29 June 1994, pp. 7 - 12.

Hughes D R, Smart P A, Manufacturing competitiveness - the role of best practice, in Platts K W, Gregory M J, Neely A D, (Eds.) Operations Strategy and Performance, Papers from the International Conference of the European Operations Management Association, Cambridge, 27-29 June 1994, pp. 505 - 506.

Hughes, D R, Smart P A, Stead, R, Wilkinson, M G, The use of animated graphical simulation techniques to support the service engineer, European Simulation Multi-Conference, Barcelona, June 1994, pp. 846 - 849.

- Hughes D R, Smart P A, The development and testing of a computer based tool to assist strategy formulation, 4th International Conference on Factory 2000, York, UK, October 1994.
- Childe S J, Smart P A, The use of process modelling in benchmarking, in Rolstadas A (Ed.) Benchmarking - Theory and Practice, Chapman and Hall 1995 pp190-199
- Maul R S, Weaver A M, Childe S J, Smart P A, Bennett B, Current issues in Business Process Re-engineering in UK manufacturing companies, International Journal of Operations and Production Management, 1995
- Childe S J, Weaver A M, Maul R S, Smart P A, Bennett J, The application of generic process models in Business Process Re-engineering, paper presented IFIP Galway 1995
- Maul R S, Weaver A M, Childe S J, Smart P A, Bennett J, The application of BPR to SME's, 2nd International Conference of the European Operations Management Assoc. University of Twente, NL, May 1995 pp305-313
- Weaver A M, Maul R S, Childe S J, Smart P A, Bennett J - The development and application of a generic 'order fulfilment' process model, 3rd International Conference on Computer Integrated Manufacturing, Singapore, 11-14 July 1995
- Childe S J, Smart P A, Weaver A M, The use of generic process models for process transformation, International Workshop on Modelling Techniques, Business Process Re-engineering (BPR) and Benchmarking, Bordeaux, France 18-19 April 1996.

Signed..... 

Date..... 31/10/96

CHAPTER ONE - Introduction

The research presented in this thesis was undertaken while the author was funded by the Engineering and Physical Sciences Research Council (EPSRC) for projects which were awarded to the University of Plymouth. During the initial stages of the work the funding was supplied for a research studentship. During the latter stages of the research the author was a member of a research team and was employed on a project (grant GR/J95010), supported by British Aerospace (Systems and Equipment), to specify a Business Process Re-engineering (BPR) methodology for small and medium sized manufacturing enterprises. This project provided the invaluable access to small manufacturing companies considered in this research.

This introduction provides the background to the research and indicates how the project has built upon previous research. The aims of the research are presented and an initial schedule of work is outlined to address the aims. The Schedule of work is expanded using the knowledge gained in the area and by addressing taken for granted assumptions identified in the initial research approach. Prior to a summary of this chapter a description of the structure of the thesis is presented.

1.1 Background

Competitive pressures within manufacturing have caused a large proportion of firms to re-think their strategies, and to develop their capabilities. Consumer demands for higher levels of product quality and diversity (Hayes and Jaikumar 1988), vast increases in product variety within markets (Wortmann 1991), and decreasing product life-cycles (Pisano and Wheelwright 1995) have all intensified the need for change.

To address this need, firms are constantly seeking to '*identify, adopt, and develop best practice*' to improve their operating performance (Voss and Blackmon 1994, DTI 1990). Best practice is often associated with 'thematic' change programmes (Smith *et al* 1994) or templates for change (Lee and Oakes 1996) which are usually 'bought in' in the form of consultancy expertise (Miller 1989). The use of consultancy services does not guarantee success (Soh 1992) however, and many SMEs find that their limited financial resources (Ibrahim and Goodwin 1986) often mitigate against the application or development of best practice via this mechanism. In cases where small firms have been able to afford the use of consultancy expertise, disappointing results have been observed (Staughton *et al* 1996).

Workbook based methodologies have been used as an alternative to consultancy intervention, for example, Mills (1995) and Neely (1996). These rely on participants from within companies to lead change projects themselves, in some cases with limited expertise. However, a limitation of this approach is the extent to which knowledge transfer might be achieved (Brody 1991).

Advancements in technology have provided the potential for computer-based mechanisms to be used to structure and manage internally led change projects, and to provide a means to create learning environments for the delivery of best practice. This research addresses the feasibility of using computer based mechanisms for intervention in SMEs, and for the transfer of best practice to small firms.

1.2 Previous Research

The research reported in this thesis builds upon previous work in the field of production and operations management (POM), to specify methodologies to help manufacturing companies improve their performance. A methodology for the implementation of Computer Aided Production Management (CAPM) systems (Hughes *et al* 1987) established the basis for the development of a strategic manufacturing methodology (Hughes 1989). The outcome of this research, a workbook-based process methodology known as STRATAGEM, has formed the basis for the development of a prototype computer based tool (prototype 1 - Chapter 7).

Previous research in the POM area has also resulted in the creation of a methodology for justifying the finance of advanced manufacturing technologies for SMEs (Larsen 1994).

This methodology, known as PROFIT, formed the basis for the development of the second prototype presented in this research (prototype 2 - Chapter 8).

The author's involvement in an EPSRC research project (Maull *et al* 1994) aimed at specifying a Business Process Re-engineering methodology for small and medium sized manufacturing enterprises has also underpinned the development of the prototype described in Chapter 10. This draws on the knowledge gained in BPR, and from the experiences of practitioners undertaking process based change projects.

1.3 Aims of the research

The overall aims of the research were to establish the feasibility of using computer-based mechanisms for intervention to improve operational practice in SMEs, and to investigate the

use of computer based mechanisms to transfer best practice. To meet these aims, work was undertaken:

- to identify and understand the difficulties SMEs have in acquiring best practice;
- to investigate existing methods for the transfer of best practice;
- to formulate objectives and potential features for computer-based delivery mechanisms;
- to specify a suitable approach for computer-based best practice delivery using the experiences gained from the development and testing of prototypes.

At the outset, it was envisaged that the aims of the research could be achieved by completing this programme of work. However, it was soon recognised that a major assumption had been made during the initial stages of the work. 'Best practice' was assumed to be a known phenomenon which could be identified and then applied in experiments with alternative computer-based delivery mechanisms for industry. However, best practice could not immediately be identified. This necessitated pre-requisite research. To achieve the research aims, work was also required to identify:

- What is best practice in manufacturing?

1.4 Contribution of the research

The major contribution of this research is in the identification and development of a new approach for intervention in SMEs for the delivery of best practice. The approach uses computer-based tools (CBTs) to support small manufacturing companies in their internally led improvement programmes. The research identifies successful characteristics of CBTs from observations of practitioner evaluations. These characteristics include:

- a structured project management approach;
- process methodology encapsulation or support;
- identifiable goals, milestones and outcomes;
- the provision of tools and techniques for learning.

While much research has been undertaken in the POM area regarding methods for improving and organising manufacturing, little research exists to address the delivery mechanisms which may be used to transfer new POM knowledge. This research has identified a successful alternative mechanism which addresses this deficiency.

The research has provided a significant contribution to knowledge in the field by:

- proposing a definition of best practice;
- providing explanations of the deficiencies of existing mechanisms for the transfer of best practice to SMEs;
- providing a new computer-based approach which alleviates some of the problems which have been identified;
- specifying the appropriate features of the computer-based approach in the context of SME requirements.

1.5 Structure of the thesis

This chapter has introduced the research project and has described its background. In addition to highlighting the foundations of previous research, the aims of the project have been presented. The development and subsequent practitioner evaluation of prototype computer based mechanisms was utilised in the research. A statement of the contribution of the research has also been provided.

Chapter 2 describes the research methodology which has been used to structure and manage the research. The methodology employed has been formulated using a synthesis of the research cycle (Meredith *et al* 1989), consisting of description, explanation and testing phases, a prototyping cycle (Pressman 1992) and a bridging research strategy (Reisman 1988). The need for the approach to address the needs of practitioners (Thomas and Tymon 1982) are also described as being central to the research.

In Chapter 3 the author addresses the meaning of the phrase 'best practice'. The chapter highlights the need for best practice in the context of competitiveness, and provides an initial definition. An understanding of best practice is further developed using World Class Manufacturing (WCM) and Lean Production (LP) as examples. The chapter indicates that the benefits for companies lie in understanding the concepts embedded within a best practice theme and adapting them to fit their specific requirements.

Chapter 4 extends the descriptive phase of the research methodology by focusing on the existing mechanisms which are available for the transfer of best practice. The chapter addresses a variety of consultancy modes of intervention, and provides a summary of the intervention characteristics. Following an identification of the advantages and disadvantages of workbook based mechanisms, the chapter also addresses the components of methodologies which are often used to structure interventions.

In order to contextualise the research for the requirements of SMEs, Chapter 5 reports on exploratory research conducted to identify the characteristics of SMEs. The chapter also

addresses issues associated with consultancy support, and reports on a number of inhibitors of change identified during a workshop with practitioners.

From a synthesis of the initial research, Chapter 6 formulates a set of objectives for computer-based mechanisms for intervention in SMEs and provides a set of features which may be incorporated into a design approach to address the objectives.

Chapter 7 reports on the development and practitioner evaluation of the first prototype. The prototype encapsulates a methodology which is concerned with the formulation of manufacturing strategies.

Chapter 8 extends the research and describes the development and evaluation of a prototype computer based mechanism to support a workbook based methodology. The methodology and supporting mechanism were developed to help companies justify the finance for advanced manufacturing technologies.

To explicitly address a knowledge transfer requirement of the computer based mechanism, Chapter 9 describes an investigation into design methods for the creation of a learning environment. Specifically, the chapter identifies characteristics of good learning, and uses a model of instructional design as a framework for the research.

Chapter 10 reports the research conducted to evaluate the use of exploratory learning environments by SMEs. The chapter presents the development of a prototype CBT to implement a node and link architecture, and describes the results of discussions with SMEs to establish the feasibility of the approach.

The final chapter, Chapter 11, provides the conclusions of the research, and proposes ways in which research in this area could progress in the future.

1.6 Summary

This chapter has introduced the need for research to be conducted to identify alternative mechanisms for the delivery of best practice for SMEs. The aim of the research is to establish the feasibility of computer-based mechanisms for intervention in SMEs, and to establish a suitable approach for the transfer of best practice. An initial programme of work has been outlined to achieve the research aim, and an assumption regarding best practice has been identified. The need for pre-requisite research has been indicated to address this assumption. The contribution of the research has been stated, and the structure of the thesis has been described.

The following chapter describes the research methodology which was used to structure the research.

CHAPTER TWO - Research Method

2.0 Introduction

The objective of this chapter is to present the research method employed in the project, and the rationale underpinning the research approach. It has been suggested that it is conceptually helpful to separate the content ('what') from the process ('how') when undertaking tasks of this nature (Harvey-Jones 1989). The information presented focuses on the process of the research and results in the development of a framework.

Bechhofer (1974) describes the research process and states:

'The research process is not a clear cut sequence of procedures following a neat pattern, but a messy interaction between the conceptual and empirical world...'

Bechhofer's view of research suggests that there is a need to identify or develop appropriate frameworks to manage the research process.

The research approach employed is based on research frameworks and strategies reported in the literature. These frameworks promote both research validity and relevance. To further support the dimension of research relevance a prototyping approach (Pressman 1992) is used. This approach enables the research to be adapted to meet the actual needs of practitioners.

Following a description of the domain to which this research is applicable, the chapter describes the research cycle employed (Meredith 1992). This cycle, combined with a prototyping approach and the identification of practitioner needs (Thomas and Tymon 1982) provides the model used for the research approach. The research strategy (Reisman

1988) adopted is also described. The chapter concludes describing the research model which has been used in this project. This model consists of a synthesis of the frameworks and strategies reported.

2.1 Identification of research domain

The target domain for the research conducted is Production and Operations Management (POM). The underlying notion of POM is to maximise the competitiveness of a company via the consideration and integration of procedures, processes, operating decisions, technology and the underlying company policies. (Voss 1984)

The evolution of the POM field is discussed by Neely (1993), who suggests that the rate of evolution has caused some confusion with Operations Research (OR) and with research in technology. Technological advancements may have been the reason for this instability, but POM is now really '*concerned with the effective selection, application and management of new technologies*' (Voss 1984).

While POM is identified as the recipient domain of the research, the underlying approach of this work requires domains to be bridged. The notion of 'bridging' is discussed in the research strategy section of this chapter (Section 2.4).

2.2 The Research Cycle

A critical assessment of the research methods used within the POM field have been conducted by a number of authors (Meredith *et al* 1989, Buffa 1982, Susman and Evered 1978). The consensus of these assessments has been the recognition that much of the POM

research effort has emphasised the methods used within the research at the expense of ensuring practitioner relevance.

Mitroff *et al* (1974) observed that philosophies of science have been seen to omit the real-world problem from the research cycle. This philosophical approach is likely to result in frameworks and theories which are irrelevant in practice.

The omission of real world problems from the research process has more recently been described by Meredith (1992) who identifies that Operations Management (OM) researchers have tended to focus their effort on 'theory-testing' research. He states:

'OM researchers have used sophisticated and powerful theory-testing methods of hypothetical constructions of operating systems which have little relation to reality and offer little or no utility to managers responsible for managing those systems in the real world.'

There is therefore a requirement to consider a research approach which facilitates the explicit consideration of the real world problem. Meredith *et al* (1989) describe a research approach consisting of a number of phases. These phases are organised in a cycle and include description, explanation and testing. This cycle is based on the three research tasks (description, prediction and explanation) provided by Emory (1985). Meredith *et al* (1989) suggest that all research investigations involve a continuous repetitive cycle containing these tasks or phases.

2.2.1 Description

Descriptive research aims to capture information and characterise it to provide an understanding of the problem situation under study. Where more detailed information is

required, exploratory research is conducted. In the case of exploratory research a particular aspect is investigated more fully based on the characterisation and understanding gained from the preliminary descriptive research. The characterisation of the problem situation and the understanding acquired provides the basis for the generation of frameworks to explain relationships between phenomena.

The description phase of this research involved an extensive literature survey of a number of domains of knowledge (Section 2.5). Greater insight into the characteristics and problems of the target domain was achieved by exploratory research in the form of interviews, workshops and action research. Access to companies was provided by the authors involvement in a project aimed at specifying a Business Process Re-engineering (BPR) methodology for small and medium sized enterprises (EPSRC grant GR/J95010) (Maull *et al* 1994).

2.2.2 Explanation

During the descriptive phase some relationships between phenomena may be identified. The explanation of these relationships may be facilitated by the construction of frameworks. These explanations may initiate the design of specific research studies, enhance the interpretation of existing research or require the generation of testable hypotheses. The result of this phase of the research is the generation of new knowledge that needs to be tested.

The information acquired during the descriptive phase of the research cycle enabled the identification of a set of objectives for the proposed approach. In addition, a set of features were postulated to facilitate the achievement of the identified objectives. Using subsets of

these features, prototype computer-based tools were designed and developed. In total, three different prototypes (hypotheses) were formulated, each facilitating a different approach to be developed and subsequently tested.

2.2.3 Testing

The third stage in the research cycle is where predictions formulated from the explanation stage (frameworks or hypotheses) are tested. Observation may be used to determine whether the formulated prediction is correct or not. This may result in modifications of, or enhancements to, the frameworks and approaches developed.

Two levels of testing may be identified for each revolution of the research cycle in the approach specified (Section 2.7). The first level is concerned with the progression of the initial prototype into a final prototype. This involved periodic revisions and evaluations of the initial proposed approach.

The second level of testing involved observing the use of the prototypes by practitioners, and discussing with SMEs the characteristics of each proposed approach.

In total, three approaches have been tested in this research. The general philosophy employed has been to test three different approaches to provide an understanding of the characteristics which may be included within a computer based delivery mechanism for intervention in SMEs. The knowledge generated from this research may be regarded as the synthesis of the results obtained from these three approaches.

2.2.4 Exclusion of research phases

The result of a short-circuit of the research cycle (i.e. skipping one of the stages) can cause problems in the research approach (Meredith 1992). If the explanation phase is excluded, frameworks and theories cannot be developed. The elimination of the testing stage from the cycle may prevent the evaluation of previous research or constrain the validation of explanatory frameworks. An approach which ignores the description phase in the research cycle is likely to distance the research findings from the real world problems encountered, and hence reduce practitioner relevance.

2.3 Research Relevance

The prototyping approach applied within the general research cycle has been used to ensure practitioner relevance. This approach has been further enhanced by the five key needs identified by Thomas & Tymon (1982) to specifically address practitioner relevance. These needs include descriptive relevance, goal relevance, operational validity, non-obviousness, and timeliness. This model has been used in conjunction with the general approach previously described.

2.3.1 Descriptive relevance

Descriptive relevance is concerned with the accuracy of the research findings in describing a particular phenomenon or problem within the application domain. It is an assessment of the pertinence of the research findings to the practitioner. These findings emerge as the study is conducted.

The research findings from this project should progress the knowledge within the field of POM to the extent that practitioners can utilise computer-based mechanisms to identify and apply concepts and principles of best practice to improve their capabilities.

2.3.2 Goal Relevance

Goal relevance is concerned with the pertinence and ability of the research output to directly affect the aspects of the application domain which the practitioner wishes to influence. The knowledge generated from the research should assist the practitioner to resolve identified problems.

The knowledge generated from this research should help SMEs to adapt or change their current work practices based on best practice knowledge.

2.3.3 Operational Validity

Many research projects in the past have concentrated on the epistemological validity of the research output. To ensure that the research effort directly aids the practitioner, an additional focus on 'operational validity' is needed. This ensures that the research findings are implementable or usable by the practitioner.

To ensure that this research is operationally valid the proposed approach should facilitate greater support for practitioners undertaking internally led improvement projects. The knowledge encapsulated within the proposed delivery mechanism should be usable and implementable in terms of improving SME capabilities.

2.3.4 Nonobviousness

This need refers to the ability of the research output to exceed the current common sense theories which the practitioner currently uses. This may be described as originality.

The knowledge generated must exceed that which is currently available to practitioners in the target domain. The approach specified from the synthesis of research findings should be new.

2.3.5 Timeliness

An emphasis on timeliness is concerned with ensuring that the research output is provided for the practitioner in time to address the problems encountered.

The research findings should be available for practitioners to overcome the current problems associated with the deficiencies of the existing mechanisms available.

2.3.6 Summary of research relevance

The five key practitioner needs described underlie the research approach. While these may not be explicitly recognised from the research model developed, they are considered throughout the research project.

2.4 Research Strategy

An additional perspective of the formulation of the research process is to address the strategy employed to progress the body of knowledge within a domain.

Reisman (1988) describes a number of different strategies for conducting research. These include ripple, embedding, bridging, transfer of technologies, structuring, creative application, and empirical validation strategies.

The most common of these strategies is the ripple strategy. This is concerned with incrementally growing a body of knowledge within a specific domain.

The strategy adopted for this research is characterised by Reisman as a bridging strategy. A bridging research approach involves generating new knowledge by connecting known theories in two or more domains. It is suggested that there is no theoretical limit to the disciplines which may potentially be coalesced. The progression of knowledge from adopting this research approach is potentially large. Reisman states:

'...very often, if not inevitably, such bridging results in major expansions of knowledge in the respective fields. The resulting whole is often greater than the sum of the parts.'

The underlying principle of the approach employed in this research utilises a 'bridging strategy'. The approach adopted in this research is to draw on pertinent concepts from a number of disciplines and integrate them to progress the knowledge within POM. The domains which have been bridged include consultation/intervention, technology, learning and POM. An in-depth understanding of the characteristics of SMEs and their needs is also required to provide the context for the proposed approach.

2.5 Literature Survey

A literature survey was conducted in a number of fields to provide the foundation on which the research could be based. Extensive use was made of the resources at the University of Plymouth including on-line searches of databases on CD-ROM together with searches of

the library's information system. In addition, a number of electronic discussion groups were used to obtain up-to-date information from both practitioners and other academics.

Extensive use of electronic mail was maintained during the project to submit and discuss relevant issues on an international basis. In addition to a large number of books, up-to-date research literature has been identified in learned journals and conference proceedings. The initial areas which were researched included:

Production and Operations Management Business Process Re-engineering

Best Practice and Benchmarking Small & Medium Enterprises

Organisational learning / training Software development

Consultation / Intervention Research Method

In depth research has been conducted into Business Process Re-engineering (BPR) as part of a parallel research project undertaken by the author. The findings of this research were utilised as an example of best practice. The third prototype developed in this research project utilised these research findings.

2.6 Prototyping

A prototyping approach has been briefly introduced in the context of the research cycle used. It was identified that the prototyping cycle may be positioned at the explanation stage and facilitates the evolution of each approach into a testable hypothesis. This section describes prototyping in more detail.

The prototyping approach is well known in the field of engineering. Prototypes of complex objects may be constructed and modified in an iterative process before resources are committed to projects (Er 1987). Similarly, in the field of information system development, prototypes have been used to provide enhancement of both developers perception of a users need and a users understanding of potential system capability. Pressman (1992) describes prototyping as a process which enables a developer to construct a model of the system which is to be built. This model can take one of three forms:

1. A paper based or personal computer based model of the human-machine interaction.
2. A working prototype that implements a subset of the functions that a system will possess.
3. A existing system that performs all or part of the function required but has feature that will be improved upon in the new development effort.

The prototypes developed and used within this research fall within categories 2 and 3. The sequence of events for prototyping is shown below (Fig. 1.1)

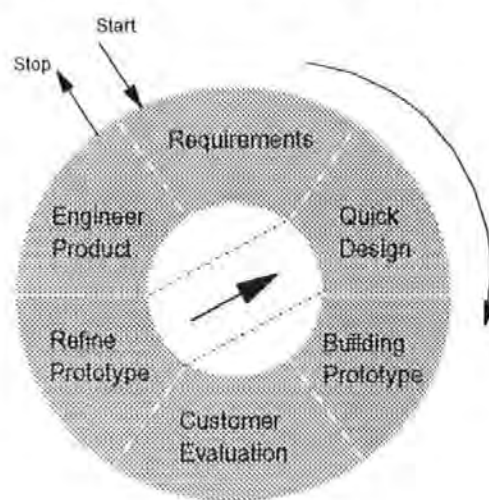


Fig 1.1 The prototyping cycle (Pressman 1992)

The model shown indicates that a process of iteration occurs as the prototype is adjusted to satisfy the needs of the customer. At the same time, this iteration enables the developer to construct a better understanding of the practitioner need.

The knowledge gained from the descriptive phase of the research was used to construct a set of objectives and features for the prototype computer-based tools (CBTs). The prototypes presented in this thesis were developed based on these objectives and features. Following the development of each prototype, evaluations were conducted through demonstrations and presentations to practitioners. For each of the three approaches developed and tested in this research project, a number of prototype versions with enhancements were developed. The 'engineer product' phase of the prototyping cycle (Fig. 1.1) was omitted during this research. The general approach employed was to facilitate the identification of characteristics and features which could be regarded as successful from the testing of each prototype. These characteristics are synthesised into research conclusions specifying an appropriate computer based approach.

2.7 Synthesis - The Research Approach

The synthesis of the research method used during this project can be seen in the research method model (Fig. 1.2) below.

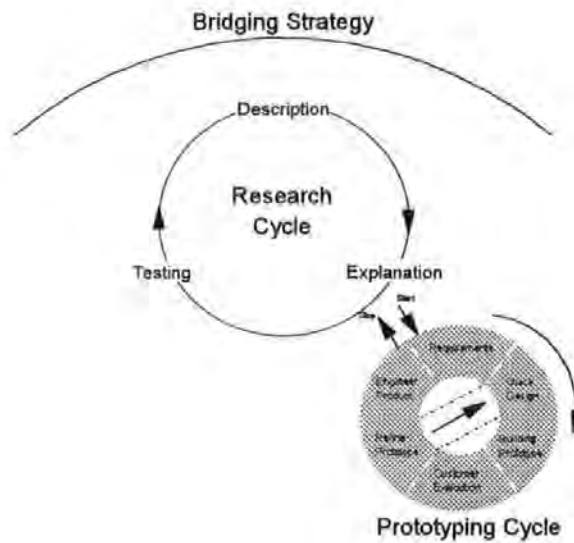


Fig. 1.2 Research method model

The research project has utilised a 'bridging strategy' which potentially facilitates '*major expansions in knowledge in the respective fields*' (Reisman 1988). The target domain for the knowledge generated by this research is production and operations management (POM), and specifically the research is conducted to meet the needs of practitioners. The practitioners may be regarded as small and medium sized enterprises (SMEs). The research output is intended for use by academics and industrialists intending to develop mechanisms to transfer best practice to SMEs.

The method used to conduct the research is a synthesis of the research cycle involving description, explanation and testing, and a prototyping cycle. Following descriptive research which includes a survey of appropriate literature and exploratory research, a prototype is developed. Following prototype development, practitioner evaluations are conducted. The results of these tests enable successful characteristics of each approach to be identified. In total three different approaches have been developed as part of this research. The generation of new knowledge may be regarded as the synthesis of the results from the testing of all three approaches.

The following chapter reports on the initial descriptive research undertaken to identify and define best practice in manufacturing.

CHAPTER THREE - Best Practice in Manufacturing

3.0 Introduction

An important pre-requisite for research into delivery mechanisms for best practice is to understand what is meant by 'best practice'. At the outset of this research 'best practice' was assumed to be an established concept. From the early descriptive research it was evident that best practice was not explicitly recognisable. No definitions or characterisation could be found. The phrase "best practice" seemed to be loosely used to describe activities which result in good performance, and was largely associated with thematic change programmes for example, Total Quality Management (TQM) and Business Process Re-engineering (BPR). This chapter explains the author's interpretation of best practice and discusses how changes in the competitive environment have caused companies to consider new ways of working.

A working definition of best practice is suggested, and a more detailed study of the concept is described. To facilitate the explanation, models of best practice are used. Specifically models of World Class Manufacturing, Lean Production, and the consideration of manufacturing improvement based on information technology are presented. The application of best practice by industry is also considered, and an explanation of its poor industrial take-up is provided. The chapter concludes by identifying the lessons learned, and indicating the implications for the proposed computer based approach.

3.1 The need for best practice

To describe and explain the need for best practice it is useful first to highlight some of the influences which have affected the competitive environment. Many aspects of the

competitive environment have changed which has resulted in organisations having to rethink their key competitive dimensions (Hamel and Prahalad 1993). Current competitive requirements have been affected to some extent by an increase in consumer power. Consumers are now seen to demand higher levels of quality and diversity, and no longer merely accept the products and services offered (Hayes and Jaikumar 1988). The markets for consumer goods have also changed dramatically. These markets are now characterised by a vast increase in variety (Wortmann 1991), and products are showing steadily decreasing product life-cycles (Pisano and Wheelwright 1995).

It is now recognised that success in manufacturing is associated with a high level of performance across many competitive dimensions (DTI 1993). It is stated that:

'The manufacturing business of the 1990's will need to differentiate itself from its competitors. This includes getting new products to market quickly, producing quality goods and services with a high degree of choice and high perceived value, lowering the cost base and offering reliable delivery and excellent customer service.' (DTI 1993)

To achieve a high level of performance in these dimensions it may be necessary for new ways of working to be established. The new ideas have been based predominantly on the capabilities of new technologies, and on the reported successes of a number of management philosophies.

Voss and Blackmon (1994) highlight this pursuit for change and suggest that firms are constantly seeking to *'identify, adopt and develop best practice'* as a means to improve operating performance and competitiveness. This view reinforces that of the Rt. Hon Michael Heseltine MP (DTI 1990). In the Department of Trade and Industry document entitled *'Managing in the '90s - the competitive response'* he states:

'The businesses with the best prospects for long term success seem likely to be those which recognise the need for positive changes: to adapt, to innovate and to plan for continuous improvement and the introduction of best practice into all their activities. Adopting best practice in marketing will help you get closer to your customers. Adopting best practice in design, development and manufacture of improved products will help you exploit the opportunities you identify. Adopting best practice in purchasing will help you make full use of the potential of your suppliers.' (DTI 1990)

Clearly, Heseltine believed that the changes in the competitive environment have changed the rules for business. New ways of working must be established to fulfil the competitive requirements identified. Heseltine proposes that companies draw on the experiences of others and utilise best practice models based on technological developments and proven management philosophies. However, the number of models and technologies present within the manufacturing arena complicates this process. Managers are confronted with the dilemma of establishing 'what is best practice'.

3.2 What is best practice in manufacturing?

Early attempts to construe best practice resulted in the formulation of a working definition (Hughes and Smart 1994). The definition was based on the perspective that a manufacturing system is comprised of interacting processes (Parnaby 1979), and that the detailed practice within a process may be identified as activities (Harrington 1992) which transform a set of inputs into a set of outputs (Churchman 1971). This provided a way to explain the physical and practical element of the phrase. The definition was also based on the process of benchmarking (Camp 1989), which was used to explain a process of comparison between two or more practices. The working definition of best practice which was formulated was:

'An activity which is better than, or equal to the standard of performance being achieved by any other activity undertaken in a sufficiently similar circumstance to allow meaningful comparisons to be made.' (Hughes and Smart 1994)

While this definition initiated a characterisation of best practice required in this research, and formed an initial platform and reference point for other research (Kennerly *et al* 1996), a more detailed study into ‘thematic models’ (Smith *et al* 1994) of best practice provided greater understanding.

Lee and Oakes (1996) suggest that the most common templates (models) for change are World Class Manufacturing (WCM), Lean Production (LP), Total Quality Management (TQM), and Business Process Re-engineering (BPR). Using descriptions of WCM and LP as examples, the remainder of this chapter indicates that to identify and transfer best practice it is necessary to look beneath the themes of the models to the concepts and principles which they encapsulate. In addition to these examples, the role of information technology is also described.

3.2.1 World Class Manufacturing

The acronym WCM or World Class Manufacturing is an example of a ‘thematic model’ which has been used to propose a set of principles for improving manufacturing practice. The following sections describe these principles highlight issues associated with the practical implementation of WCM.

3.2.1.1 Principles of World Class Manufacturing

The table shown below (Table 3.1) indicates 19 principles of the WCM model adapted from Schonberger (1990). It may be argued that the principles of the model provide useful guidance for practitioners regarding ‘what’ may be changed in manufacturing. However, additional information is likely to be required to inform practitioners ‘how’ the work practices of a company might change.

Heading	Principle
General	Get to know the customer Get to know the competition Continually improve quality, cost, response time, flexibility
Design and Organisation	Cut numbers of components, operations, suppliers Cut number of flow paths Focus organisation on product or customer
Operations	Cut flow time, distance, inventory and space Cut set-up, changeover, get ready and start-up time Operate at customer's rate of use
Human Resource Development	Implement cross training, education, job switching Develop team ownership of products, processes
Quality and Problem Solving	Encourage error free products (Total Quality) Record and retain quality data Encourage problem solving by line staff
Accounting and Control	Cut transactions and reporting, control causes not costs
Capacity	Maintain and develop current resources prior to purchasing equipment and automation Automate incrementally when process variability cannot otherwise be reduced Develop plural workstations, machines and cell for each customer or product family
Marketing	Market and sell capabilities on offer

Table 3.1 - principles of WCM

From this study of WCM it may be suggested that the proposed computer-based intervention approach should deliver knowledge to practitioners regarding the principles of a best practice model.

3.2.1.2 Practical implementation of World Class Manufacturing

Schonberger (1986) describes the underlying goal of WCM as the *continual and rapid improvement* of quality, cost, lead-time, flexibility and customer service, and suggests that improvements in all of these criteria should be pursued in concert. This may be achieved by developing work practices based on the principles described.

New (1992) acknowledges that *'you can become better at everything simultaneously'*, but suggests that trade-offs such as those associated with customisation/standardisation are unavoidable. A number of examples are provided to highlight how the 'new wisdom' of the WCM model has affected these trade-offs. This includes for example:

'Design flexibility versus lead time - Customised products can be made to order only on long lead times.' However, with the wisdom of the WCM model, *'modular products allow very short response times but true customisation still takes a lot longer to produce than an equivalent standard product.'* (New 1992).

It can be recognised that although the time taken to deliver a customised product is reduced (improvement), a trade-off still occurs.

Drawing on the work of New (1992) regarding the implications of the practical implementation of WCM, it may be suggested that the proposed computer-based approach should provide practitioners with guidance regarding the practical implementation of best practice.

3.2.1.3 Identified issues

It has been suggested that the benefit of adopting 'best practice' is from both the understanding and the application of the concepts and principles concerned. This indicates that to transfer WCM best practice, there is a need to transfer knowledge regarding both the underlying concepts and principles of the model, together with the issues associated with practical implementation.

3.2.2 Lean Production

Lean Production (LP) is another example of a 'thematic model' of best practice which provides approaches to improve manufacturing (Harrison and Storey 1996). Both research and practice of LP have received much attention since the five year world-wide study of the automobile industry conducted by MIT. The subsequent publication of the book 'The Machine that Changed the World' (Womack *et al* 1990) has not only raised the awareness of managers and researchers to the principles of LP, but also has been successful in tying together many of the principles found on a variety of research agendas.

This section briefly describes Lean Production, and the effect that the Company's environment has on selecting and implementing models of best practice is highlighted.

3.2.2.1 Principles of Lean Production

Krafcik and McDuffie (1989) describe Lean Production as:

'It uses less of everything compared with mass production - half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a product in half the time. Also, it requires far less than half the inventory needed on site, results in many fewer defects, and produces a greater and ever-growing variety of products.'

A more simplistic description using systems ideas to illustrate the Lean Production model has been provided by Katayama and Bennett (1996). Lean Production in this context may be described as requiring less resource input for greater performance output. Less resource input may be characterised as '*less material, fewer parts, shorter production operations, less unproductive time needed for set-ups*', whereas the performance output may be characterised by '*better quality, higher technical specifications, greater product variety*' (Katayama and Bennett 1996).

Karlsson and Alstrom (1996) distinguish between the goals of LP and its associated principles. Table 3.2 is adapted from Karlsson and Alstrom's model. The table shows six key principles and their associated areas of concern.

Principle	Area of concern
1. Elimination of waste	Levels of inventory Production run time between set-ups Set up time Machine down time Scrap Re-work
2. Continuous improvement	Employee involvement Suggestions for improvement
3. Zero defects	Process control Worker responsibilities Reduction in Quality Control
4. Just-in-time (JIT)	Production run-time between set-ups Work in progress (WIP) Order processing Scheduling (pull system)
5. Multi-functional teams	Competences of employees Supervisory responsibilities Integrated functional activities (e.g. procurement, maintenance)
6. Information provision	Timely information Strategic information Operational information

Table 3.2 - Principles of Lean Production

As in the case of the WCM model, it is possible to recognise the benefits of adopting the concepts embedded in the LP model. Highlighting the 'elimination of waste' principle as an example, it is possible to envisage improvements which may be achieved by developing work practices based on each associated area of concern. However, Karlsson and Alstrom state that:

'...it is not advisable to eliminate inventory mindlessly. Instead, the reasons for the existence of inventory must first be removed.'

This further supports the need for practical guidance when considering the transfer of best practice. The way in which the principles of best practice may be implemented by practitioners is a key concern to ensure the goal relevance (Section 2.3.2) of the proposed approach

Having identified that best practice is associated with the identification and implementation of the concepts and principles embedded within such models as these, and that the transfer of best practice is associated with the delivery of different categories of knowledge (i.e. theoretical and practical), the following section builds on this understanding of best practice and indicates the need to adapt the concepts to fit individual company requirements.

3.2.2.2 Fit to the environment

Katayama and Bennett (1996) indicate that changes in environmental conditions have now cast doubt on the applicability of the LP model. They suggest that the threat of imports and the obsolescence of products resulting from rapid product introductions and variants have caused the appropriateness of the Lean Production model to be questioned.

This potential mismatch between practice and environment at the macro level may provide useful guidance for companies. It may be postulated that the principles embedded within best practice models should be adapted to fit the needs of individual competitive environments at the micro level. This indicates that the delivery of best practice should not be prescriptive but adaptive.

3.2.2.3 Identified issues

The example of the LP model of best practice supports the requirement to provide knowledge regarding the principles and concepts of the model, together with practical guidance on how the work practices may be improved. It has also been suggested that best practice should be adapted to fit the requirements of a company and should not be prescribed.

3.2.3 The role of information technology

In addition to models of best practice which are based on new manufacturing and management philosophies, work practices may also be improved by utilising the capabilities of new information technologies.

3.2.3.1 Information technology as best practice

The promise of manufacturing technology to gain improvements in cost, quality, flexibility, delivery, speed or design has been indicated by Hayes and Jaikumar (1988). Innovations in technology provide a host of potential ways of working which may enable the demands of competitive manufacturing to be met. Ptak (1991) analyses a range of concepts and technologies (MRP, MRPII, JIT, OPT, CIM) and concludes that:

'...the future success of manufacturing cannot depend on only one of these concepts; a company must draw from the entire gamut to extract what makes sense for that particular company.' (Ptak 1991)

This supports the notion that to deliver best practice the orientation should not be prescriptive, but should allow companies to make informed judgements on the appropriateness of best practice for themselves. Learning the concepts and principles of best

practice is key in the process of adaptation. This is supported by the findings of the Canadian Advanced Manufacturing Technologies mission to Japan in 1985 described by Thomson and Graefe (1989):

'...it became very clear to the mission's members that technology itself is not the answer; it is not robots, automatic storage and retrieval systems, automatically guided vehicles, numerically controlled machines, Programmable logic controllers, or any other component of automation....while computers provide the mechanisms for the solution, it is the paradigm and understanding the implications of the paradigm that lead to better manufacturing...'

3.2.3.2 Identified issues

While information technology may provide potential solutions to manufacturing problems, companies need to consider the appropriate technologies which meet their requirements.

New technologies only provide the mechanisms for the solutions. The development of best practice requires an understanding of the implications of adopting new technology.

3.2.4 Application of best practice

The theoretical models presented provide valuable insight for practitioners. Although it is interesting to debate the potential benefits of practices based on these principles, the key test is to establish their take-up by industry. As described in Chapter 2, a key requirement of this research is to maintain practitioner relevance. This section describes key factors associated with the application of best practice models.

3.2.4.1 Take-up of best practice by industry

Voss and Robinson (1987) conducted a survey of 132 UK companies and concluded that the take-up of the Just-In-Time (JIT) philosophy is particularly poor. Where JIT implementation was found they state:

'...many companies are implementing just a subset of JIT, and the data suggest that companies are focusing on the easy to implement techniques rather than those giving the greatest benefits.' (Voss and Robinson 1987)

A possible explanation of poor take-up is that companies fail to move beyond the early stages of their improvement initiatives. Authors such as Safayani *et al* (1991) and Plenert (1993) describe different stages of adoption for the implementation of JIT. Plenert (1993) describes four categories ranging from merely labelling an initiative as "JIT" to the implementation of a plant wide JIT management philosophy.

It is likely that the failure to move from the 'labelling' stage to full implementation is the result of a poor understanding of the concepts and principles associated with the philosophy (Peters 1987).

3.2.4.2 Explanation of poor take-up

Whittle *et al* (1992) found that a number of companies embarking on the procurement of manufacturing solutions attempted to copy 'best practice' from 'model' companies. Best practice cannot be purchased simply by adoption, it is highly unlikely that the institutional and contextual variables will remain constant to permit the transfer of practice from one organisation to another (Whittle *et al* 1992). In a similar context, Teece, Pisano & Shuen (1992) describe company resources as 'firm-specific assets'. These assets may take the form of specialised production facilities or experienced engineers and are '*difficult if not impossible to imitate*'. This could explain the poor take up of best practice and the inability of some companies to progress past the labelling stage.

Schein's (1984) model of organisational culture is used to explain the limitations of copying best practice. Schein's model consists of three levels.

The first level is termed *visible artefacts* and includes for example, organisational architecture, technology and plant layout. It is possible to observe 'how' a group constructs its internal environment and 'what' patterns of behaviour are present, but it is difficult to identify the logic concerning 'why' a group behaves in a certain way, or 'why' the physical artefacts are organised in a particular way.

To understand 'why', the *values* that govern both behaviour and decisions must be analysed. However, values are impossible to observe, and must be inferred from interviews with company personnel.

The third and most detailed level of analysis is the underlying *assumptions* of an organisational culture. These are typically unconscious but determine how group members perceive, think and feel (Schein 1983). These assumptions may be *taken for granted* within the culture and are difficult to identify and change.

It is suggested that companies which are attempting to 'adopt' or copy best practice, are attempting to change the physical artefacts within their environment (Whittle *et al* 1992). This often involves physical changes to practices without consideration of the rationale for the changes (values). Changes at the artefact level alone could be the cause of many improvement initiatives being labelled 'unsuccessful'.

Companies attempting to develop and adapt best practice must understand the principles and underlying conceptual basis, which will result in a re-appraisal of their values. Support for a change in values is provided by Lopez and Houghton (1993) who draw experiences

from a survey of nineteen electronics firms. They suggest that the greatest benefit of change is from the understanding and organisation of production and not from the best practice models themselves. This view argues against an approach based on copying best practice from model companies. However, a possible approach is to learn from the experiences of these companies when improving the capabilities of manufacturing.

Companies wishing to implement best practice should identify best practice knowledge and formulate their own configurations pertinent to their own situation. This strategy is based on learning from the experience of others, which provides a source for the creation of novel ideas. This concept is described by Juran (1989) in his address to the winners of the Malcolm Baldrige National Quality Award (MBNQA):

'Whatever the winners did to get those results, the fact that they did it proves it was doable. However, to learn from experience requires a transfer of knowledge. Such a transfer of know-how should not be done by mimicking what the winners did. Mimicking is risky because of the differences in retrospective cultures. A reliable-transfer of know-how requires thinking through what are the lessons learned...'

3.3 Conclusion

Best practice has been described using an initial working definition, and two examples of best practice models. The study has also included the consideration of issues associated with the use of new technologies to change work practices.

The research has indicated that the principles encapsulated within 'thematic models' provide useful guidance for practitioners regarding what could be changed in manufacturing. It has been shown that practical guidance is required to help practitioners implement changes to their work practices. Best practice should be adapted to fit the needs of specific company environments, and should not be simply copied from exemplar companies. New

technologies provide potential mechanisms for developing best practice, but to do this requires an understanding of the implications of adopting technological solutions.

The poor take-up by industry of 'thematic models' of best practice has been described. It has been suggested that companies have attempted to adopt best practice from exemplar companies. The changes which may have resulted from this adoption may be explained as changes to the physical artefacts within an organisation, without a consideration of the rationale for the changes. Changes at the artefact level alone may be the cause of many improvement initiatives being labelled unsuccessful and may explain the poor take-up of best practice by industry.

This work has implications for the proposed computer based mechanisms. The mechanisms should:

1. transfer knowledge regarding the principles and concepts of best practice;
2. facilitate the adaptation of best practice to fit specific company requirements;
3. provide practical guidance for the implementation of best practice.

To address these requirements, the proposed approach must deliver both theoretical and practical knowledge. This knowledge should guide practitioners in the identification and development of appropriate best practice.

The following chapter describes the research undertaken to identify the characteristics of modes of intervention and existing delivery mechanisms for the delivery of best practice.

CHAPTER FOUR - Modes of intervention and existing delivery mechanisms

4.0 Introduction

The previous chapter described best practice and identified that the experimental computer based delivery mechanisms should provide practitioners with knowledge regarding the principles of best practice together with practical guidance for implementation. Best practice has been explained in terms of a knowledge centred approach, where the concepts associated with a model of best practice must be effectively transferred in order to overcome the issues associated with the adoption of physical artefacts.

This chapter focuses on how best practice is currently delivered. The objective of the chapter is to identify the existing delivery mechanisms which may be used to obtain best practice. The research considers consultation and workbooks and focuses on the modes of intervention which may be used. The use of methodologies to facilitate project based intervention is also discussed, and a framework of the general elements of a methodology is identified.

From a study of modes of consultancy intervention, and the consideration of workbooks, a set of characteristics are identified which may be used to develop a framework of features for computer based delivery mechanisms. This framework is described in Chapter 6.

4.1 Consultation

Within industry there has been a substantial growth in the use of consultancy services. David Miller, the President of the Management Consultancies Association (MCA), puts forward several reasons for this growth (Miller 1989). Of these reasons the most relevant

for the manufacturing sector is the increasing popularity of cure-all management philosophies. These philosophies include, for example, Total Quality Management (TQM), Just In Time (JIT) and Business Process Re-engineering (BPR) and are usually imported into a company via the help of external management consultants.

A definition of management consulting is provided by the London Institute of Management Consultants:

'The service provided by an independent and qualified person or persons in identifying and investigating problems concerned with policy, organisation, procedures and methods; recommending appropriate action and helping to implement these recommendations.'
(London Institute of Management Consultants 1974)

Management consultants are confronted with a variety of problems. Markham (1992), suggests that these problems may be conceptualised as a spectrum ranging from a technical to a strategic orientation. The following descriptions provide an overview of these problem types and are paraphrased from Markham (1992).

Technical problems are not confined to technology, but also include consultancy that is carried out by specialists applying standard techniques. The problem solving process may utilise a standard approach to identify solutions. Problems of this type are usually well defined.

Strategic problems are concerned with the issues which must be addressed to determine how a particular business is to develop. Organisational issues are frequently the key factor during problem solving. These issues are usually complex and unique to individual circumstances. A problem solving process is applied rather than using a standard approach

found towards the technical end of the spectrum. The application of a strategic problem solving process may resolve ill-defined problems.

Given this interpretation of consultancy problems (Markham 1992), it is useful to consider the roles and intervention modes used by consultants. A useful framework that illustrates the roles of a consultant and the intervention modes used is provided by Blake and Mouton (1990) (Fig 4.1).

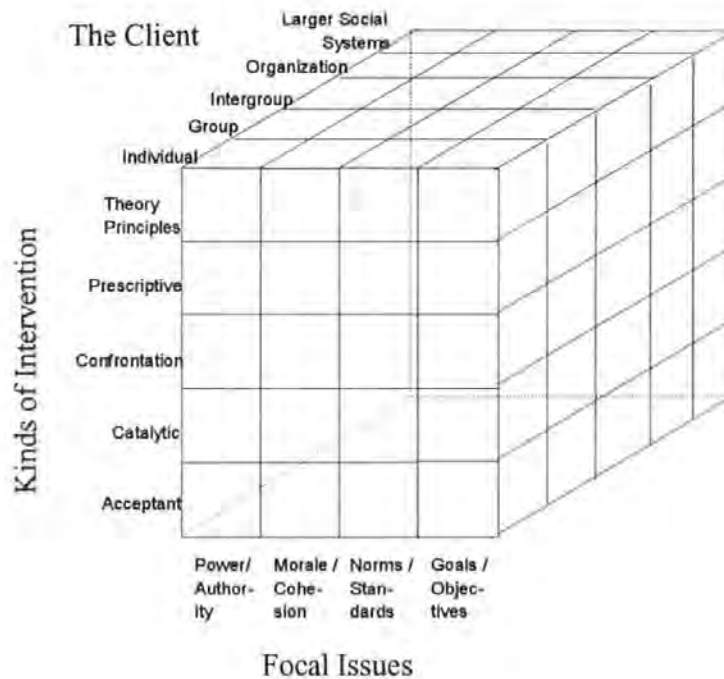


Fig. 4.1 - roles of consultants

An interaction between consultant and client may be described as having three dimensions: 'the issue', the organisational problem which the consultant is to help or resolve, 'the client', the person(s) the consultant is to help, and the 'intervention', the approach the consultant uses to solve the clients problem. This research is concerned with the intervention the consultant uses to address a problem. The following descriptions of interventions are

paraphrased from Blake and Mouton (1990). The characteristics of each intervention which might be used in the design of the proposed computer based approach are also described.

4.1.1 Acceptance Interventions

'Acceptance interventions assume that negative emotions block effective problem solving in the client company. The consultant offers support, such as emphatic listening, to help consultees become more objective.' (Blake and Mouton 1990)

This kind of intervention is needed when emotions such as frustrations, anger or anxiety for example, form a barrier for effective problem solving. The aim of the intervention is to release tension to facilitate the analysis of the problem. A consultant accepts the perspective of the client by sympathetic listening and support but does not adopt a partisan point of view. The consultant's objective is to break the client's cycle of behaviour.

Information relevant to the situation is encouraged from the client. The consultant practices active listening and helps clarify the client's feelings. The situation is not judged by the consultant, but encourages the client to identify the problem and to think through ways of addressing it.

It is difficult to envisage how the proposed computer based approach may be used for sympathetic listening. However, the characteristics of this mode of intervention which may be used are:

- to encourage information regarding the problem;
- to encourage problem identification;
- to encourage the generation of a solution by the client.

4.1.2 Catalytic Interventions

'Catalytic interventions assume the dysfunctional behaviour is caused by lack of factual information and seeks to broaden the consultees' perspectives by providing new information or verifying existing information.' (Blake and Mouton 1990)

The aim of a catalytic intervention is to assist the members of the enterprise to identify and define their problems, and to accelerate the rate at which the process of change is occurring.

The consultant provides new information or verifies existing information to bridge a gap between what is known by the client and what is needed to be known to effectively undertake appropriate action.

Information about the problem is collated and used in the problem solving process. This results in an increased rate of change, and may alter the clients perception of the problem.

This information may take the form of procedural suggestions to help the client gather appropriate information, and may include the introduction of appropriate research methodologies. Information is provided in a tentative manner to avoid client resistance.

Decisions regarding appropriate action are the responsibility of the client under the guidance of the consultant.

The ideas for the proposed approach which may be drawn from the characteristics of this mode of intervention are:

- collation of information for the problem solving process;
- presentation of new information or re-statements of problem information;
- guidelines for information gathering;
- Client responsibility for decision making.

4.1.3 “Confrontative” Interventions

‘Confrontative interventions assume that inappropriate or unjustified beliefs or values block consultees from effective actions. The goal is to aid them in identifying these values and beliefs and in understanding their implications.’ (Blake and Mouton 1990)

A “confrontative” intervention is useful to challenge the basis of the client’s thinking. Often people within workgroups hold different values, but a failure to agree in these situations may constrain effective progress. This intervention involves the consultant challenging the clients thinking regarding different courses of action, and provides the client with a different perspective of a situation. This may be achieved by the presentation of facts, counter arguments and logic.

The characteristic of this intervention which may be used in the design of the new computer-based approach is:

- the presentation of counter arguments and facts to challenge an intended course of action.

4.1.4 Prescriptive Interventions

‘Prescriptive interventions assume the consultees lack the skills or time needed to diagnose and solve problems. The consultant seeks to give consultees an expert diagnosis and a recommendation for appropriate action.’ (Blake and Mouton 1990)

This mode of intervention provides a client with two main services.

The first service is the identification of the cause of a particular symptom. The consultant provides an independent examination which results in a diagnosis of the problem. The presumption of this intervention mode is that the client lacks the knowledge, skill or objectivity to analyse the situation and plan the necessary action.

The second service is the prescription of an appropriate course of action to rectify the identified problem.

A number of assumptions of this type of intervention are described by Cash and Minter (1979), and Schein (1987). A common assumption is that the client is willing to adhere to the prescription of the consultant. To overcome a reluctance to implement the suggested action, the result of a prescriptive intervention may be given directly to senior management within the organisation. The power and authority structure may then be used to implement the suggested changes. However, this course of action may in turn result in a new set of problems which requires corrective action.

Prescriptive interventions supply a number of characteristics which could be used in the development of the proposed approach. These include:

- the identification of a cause of a problem;
- the provision of a diagnosis of a problem;
- the prescription of an appropriate solution.

4.1.5 Theories and Principles Interventions

'Theories and principles interventions assume the consultees lack concepts or principles to guide them in problem solving. The consultant helps them to acquire and integrate the knowledge needed.' (Blake and Mouton 1990)

The aim of this intervention is to encourage clients to move away from a non-theoretical basis for action to a theoretical basis for action. While there are many descriptions of what constitutes a theory, Blake and Mouton (1990) describe it as:

... a set of explicit statements as to what or will not occur.

The value of this perspective of a theory is that predictions may be made that can be tested under particular circumstances.

While Blake and Mouton relate to theories of behavioural science, it is also possible to apply other theories to a given problem, for example, the analysis of business processes using systems theory (Churchman 1971). This theory provides a reference point which may be used to consider the emergent properties of a process from a systemic perspective (Maull *et al* 1995). If a client internalises this theory, then he or she may make an assessment of the potential impact on the whole process (emergent property) an improvement initiative offers.

Theories which have been internalised by a client are likely to affect the problem solving approach. This may include for example, a rejection of a course of action when it is inconsistent with the theory based frame of reference.

The central notion of this mode of intervention is the provision of theoretical frameworks and theories to help companies understand and address problems. The characteristic of this intervention which may be incorporated in the new approach is therefore:

- the provision of theoretical model and frameworks.

4.2 Process Consultation

Schein (1987) describes a model of consultant intervention where the emphasis is on facilitation of the problem solving process. This approach to consultation is termed Process Consultation. This model provides additional characteristics regarding the process of intervention which may be incorporated into the approach proposed in this research.

This method of consultation endeavours to eliminate the problems which exist in an expert-client relationship. When an expert provides specific action which is derived from the knowledge he or she possesses, it is possible that the client may misunderstand or mistrust the expertise conveyed. Clients may sense that all is not well or that things could be better, but they do not have the tools with which to translate their vague feelings into action steps.

The goal of the process consultant is primarily to transfer the necessary skills to facilitate ongoing self diagnosis and solution implementation.

Schein (1987) describes the process consultation model in detail. The following text is paraphrased from Schein. The most central premise of process consultation is that the client owns the problem and continues to own it throughout the consultation process. It is a key assumption of process consultation that the client must share the diagnosis of the problem, and must be actively involved in remedy generation. This notion is central to the effective implementation of the model. The client ultimately knows what is possible and what will work in his cultural situation. Not only does this approach increase the likelihood that the immediate problem will be solved, but enhances the problem identification and solution skills of the client. This enables the client to continue to address and solve problems after the consultant leaves.

Information about the problem to be solved may be difficult to identify and obtain. A collaborative process of the consultant working with the client and other members of the organisation can enhance the identification and elicitation of relevant issues and information.

This use of the consulting process to pass on data gathering and problem solving skills is a key advantage over prescriptive types of intervention.

This model of consultancy indicates a number of characteristics which may be feasible for use within the proposed approach. These characteristics include:

- the provision of tools and techniques to implement problem solving;
- the transfer of skills for client diagnosis and implementation;
- the provision of guidelines for information gathering;
- the direct involvement of the client in decision making.

Having identified a set of characteristics of a number of consultancy approaches, the following section describes a workbook based approach for intervention.

4.3 Workbooks

An alternative mechanism for intervention is the use of workbooks. Workbook based approaches may be facilitated by consultants, or alternatively by internal company personnel acting as internal facilitators. Workbook approaches, such as Mills (1995), Neely (1996) provide a structured approach for problem solving and improvement projects. To assist companies in achieving each stage in the workbook a set of tools and techniques is generally provided. These may include proformas, templates providing appropriate assistance for gathering information, and frameworks for analysing the information. The results of a particular analysis performed at one stage of the workbook process may inform the company of the next appropriate stage to address. Where judgements are required, the analyses may be assessed by a group and consensus may be sought regarding appropriate action.

Workbooks essentially provide a project management plan for change, and may provide similar assistance to that exemplified in the process consultation intervention. Analytical techniques may also be transferred to the client organisation using this mechanism, together with theoretical frames of reference to support analytical and decision making activities.

It is important to identify the extent to which expertise and skills may be transferred using a workbook based approach. Chapter 3 of this thesis established that to transfer best practice, there is a need to transfer the knowledge. Frequently, the epistemological orientation (Brody 1991) of many workbook approaches is that of transmission.

'Knowledge is transmitted from the teacher or text to the learner. Learning is transferring knowledge and skills from teacher to learner.' (Brody 1991)

In the authors view this is the implicit assumption of most workbook style approaches.

Knowledge transfer is assumed to take place as the user works through the workbook.

An alternative orientation is that of Transformation. The features of this orientation may be characterised as;

'..knowledge is dynamic, changing and is constructed by the learner. Knowing is contextual. Learning is a change in learners experiences and values..' (Brody 1991)

While there are obvious benefits of workbook approaches, such as the provision of a step by step guide for the analysis and implementation of solutions, it is envisaged that the use of computer based tools for interventions in SMEs may facilitate a transformation orientation via the provision of dynamic simulation and modelling tools.

The features of workbooks, such as a structured sequential approach, and the provision of techniques for project management may be used in the design of the proposed computer based approach.

Workbooks may be recognised as a vehicle for operationalising methodologies.

Methodologies provide a means for structuring large, complex intervention processes, and are often used as the basis for the consultancy interventions described previously¹. A more detailed description of the components of a methodology is provided in the following section.

4.4 Methodologies

To facilitate the process of intervention, both consultants and workbooks often use a methodology. The following sections describe what is meant by a methodology and is based on previous work (Smart *et al* 1996).

The meaning of the term "methodology" in the context of this work, has been adapted from Checkland (1981) and is paraphrased as:

'the description, explanation and justification of the use of a set of methods (tools and techniques) to produce a required outcome.'

This description echoes in part that of Jayaratna (1994) who suggests that:

'a methodology should tell you what steps to take and how to perform those steps but most importantly why those steps should be taken.'

¹ Coopers and Lybrand - breakpoint strategies for BPR

Avison and Fitzgerald (1988) have proposed a framework for comparing methodologies. This framework has been adapted to provide a generalisation of the basic elements a methodology and has previously been reported (Smart *et al* 1996). The framework resulting from this work consists of nine elements including objective, target, conceptual framework, scope, structure, tools and techniques, participants, outputs, and delivery mechanism. These may be summarised as:

Objective - The objective of the methodology may be defined as the intended outcome which would result from the application of the methodology. There may be a number of additional objectives that are difficult to define but which emerge from participation in the methodology.

Target - The target is the area where the methodology has been designed to be applicable. The target of a methodology could be all companies in a particular grouping or industry sector.

Conceptual framework - the basic conceptual framework used. For example, a systems development methodology uses the basic conceptual framework of systems. If the methodology is concerned with systems in small companies, "small companies" is also part of the conceptual framework.

Scope - that which the methodology is intended to encompass. For example, a systems development methodology may encompass the life cycle of a system from design through to implementation, while a design methodology may address only the design stage.

Structure - the structural element of the methodology guides the use of the methods in, for example, a cyclic structure or a step by step systematic structure. The structure provides a framework which may dictate the order in which participants encounter each component of the methodology.

Tools and techniques - provide a means to achieve the required output for each structural component of the methodology. For example, the use of an entity relationship technique to specify a required data model.

Participants - the element that describes the intended participants in the methodology who will carry out the tasks, e.g. the intended participants in a user-led systems development methodology would be users of the system assisted by facilitators.

Outputs - the result of the accomplishment of each structural component of the methodology. Outputs may also be described as deliverables or milestones.

Delivery mechanism - the medium or 'vehicle' used to present the methodology to the intended target, e.g. software, work book, consultant facilitation. This may be referred to as '*what purchasers actually get for their money*' (Avison and Fitzgerald 1988)

While this research is predominantly concerned with the delivery mechanism element, the author recognises that every element of a methodology cannot be mutually exclusive. For example, the consideration of the levels of expertise and competences of the participants of the methodology is likely to affect the design of the delivery mechanism. In addition, the

required output from the methodology and the levels of expertise of the participants is likely to constrain the selection of appropriate techniques. The selection of appropriate techniques will in turn affect the design of the delivery mechanism.

4.5 Conclusion

As stated in the introduction of this chapter, the objective of this phase of the research was to identify issues associated with existing delivery mechanisms and modes of intervention.

The research has identified a number of characteristics which may be used in the proposed computer based approach. These characteristics include:

- to encourage information regarding the problem;
- collation of information for the problem solving process;
- the provision of guidelines for information gathering;
- the provision of theoretical model and frameworks;
- presentation of new information or re-statements of problem information;
- the presentation of counter arguments and facts to challenge an intended course of action;
- the transfer of skills for client diagnosis and implementation;
- to encourage problem identification by the client;
- the identification of a cause of a problem;
- the provision of a diagnosis of a problem;
- the prescription of an appropriate solution;
- to encourage the generation of a solution by the client;
- the direct involvement of the client in decision making;
- the provision of tools and techniques to implement problem solving.

At this stage of the research no attempt has been made to disqualify inappropriate characteristics of interventions. It is envisaged that this disqualification will result following a study of SME characteristics. The research approach adopted is to match appropriate intervention characteristics to SME characteristics. This results in a set of features which may be incorporated into the proposed approach.

The following chapter presents the results of descriptive research and detailed exploratory research to identify the characteristics of SMEs.

CHAPTER FIVE - Characteristics of Small and Medium Enterprises

5.0 Introduction

The previous two chapters have discussed the main issues of concern for the research. This has included a description of best practice and its associated issues, and a framework of current intervention modes and mechanisms which may be used to deliver best practice.

To develop the research this chapter describes the characteristics of SMEs that must be considered when developing computer based mechanisms as a new alternative for traditional intervention methods for the small firm sector. The chapter reports the findings both from a literature search and a workshop attended by representatives from SMEs. The objective of the workshop was to ascertain first hand the issues inhibiting change in SMEs.

The chapter is divided into three main sections. The first section describes the characteristics of SMEs and is sub divided into general characteristics and technological characteristics. The general characteristics address issues such as the financial resources, time available and expertise present to support business change and development. The technological characteristics describe the feasibility of adopting new technologies and techniques to initiate and support business change. The second section builds upon the discussion regarding modes of intervention (Chapter 4) and reports on the results of surveys reported in the literature concerned with the use of consultancy services by SMEs. The final section, section three, describes a workshop which was used to identify 'inhibitors of change' within SMEs. The results are categorised in terms of inter-group trends and group specific issues. This categorisation is used to explain the characteristics of SMEs grouped according to the extent of their functional orientation (Mount *et al* 1993).

5.1 Characteristics of small and medium enterprises

Manufacturing SMEs have been acknowledged as forming a significant part of the UK economy (Dale and Kerr 1995, Teaching Company Directorate 1995). While SMEs are important to the economy there is also a growing recognition of their vulnerability in competitive markets (Staughton *et al* 1996).

SMEs have been defined using a number of different criteria. Brooksbank *et al* (1992) have suggested that the criteria of sales turnover, number of employees and chosen growth strategy should be used to distinguish between large and small firms. Houldsworth (1992) classifies an SME as having less than 250 employees and less than £20m turnover. This definition is similar to that of the Teaching Company Directorate (1995) who suggest the criteria of less than 250 employees, turnover less than £16m or balance sheet total of less than £8m, and less than 25% owned by a company not meeting SME criteria. The definition used for EC initiatives such as the Community Action Programme for Education and Training in Technology (COMETT) for example, identify an SME as having less than 500 employees. This latter criteria has been used to identify SMEs for this research.

The research conducted into identifying the characteristics of SMEs has used both the literature and practitioner observation and discussion. In the majority of cases the characteristics identified in the literature have been supported by the author's observations. The characteristics may be divided into general characteristics and technological characteristics.

5.1.1 General characteristics

Many authors, for example Ibrahim and Goodwin (1986), have pointed out that SMEs have limited financial resources to facilitate change and organisational development. This is a major constraint given the high costs associated with the most common intervention mechanism available - consultancy.

In addition to financial restrictions, further constraints are imposed by a short range management perspective (Ibrahim and Goodwin 1986, Welsh and White 1981). These characteristics of small firms play a significant role in restricting the introduction of best practice using the existing mechanisms available. For a small firm to identify an appropriate best practice there is a need first to establish the strategic intention of the company which requires a longer range perspective. It is unlikely that appropriate practices would be adopted and developed if there is no appreciation of corporate strategy.

It has also been identified (Ibrahim and Goodwin 1986) that small companies often lack trained personnel to implement business change. Many of the problems faced by smaller companies are not dissimilar to those encountered by their larger counterparts. However, SMEs have to deal with these problems without the specialised staff expertise and financial support that is found in larger companies. This implies that SMEs need to focus on the training of staff to address deficiencies in expertise. This could be facilitated by a mechanism which is not capital intensive.

Handy *et al* (1988) discuss the commitment to training by SMEs;

'...nor are they prepared to spend time and money on any form of education or training which does not have an almost immediate payoff...' (Handy *et al* 1988)

This view is complemented by Price Waterhouse (1991) who acknowledge the flexibility and dynamism of SMEs but indicate the inability of SMEs to undertake training on a large scale due to the lack of staff resources and time. The use of educational technologies which may facilitate a more flexible means for training could provide the new opportunities which are required in this area (Balcon 1990).

It is suggested by Houldsworth (1992), however, that despite the interest in Technology Based Training (TBT) and training for SMEs, the literature indicates that there is little evidence of it being applied in SMEs. In addition, although previous literature addresses Computer Based Training (CBT), multimedia, and cognitive psychology, little of this literature relates to business or management development (Houldsworth 1992) in an SME context. However, Drinkall (1989) suggests that the case for Technology Based Training (TBT) is strengthening as companies recognise the need for a highly skilled workforce in the current competitive marketplace.

These findings reinforce the need to transfer knowledge to SMEs and to develop more flexible mechanisms for developing company personnel.

5.1.2 Technological characteristics

The characteristics identified in this section relate to the issues which support or constrain technological change in SMEs. The implementation of Advanced Manufacturing Technology (AMT) and the introduction of management philosophies are considered in this section.

The financial constraints identified (Ibrahim and Goodwin 1986) suggests that the majority of SMEs would be unable to pursue the implementation of AMT because of the high costs associated with its adoption. While the financial resources of SMEs are comparatively restricted compared to larger companies, observations from the manufacturing plants of small companies have indicated a large investment in production capabilities for example, Computer Numerically Controlled (CNC) machine tools.

The advantages of AMT for small companies have been documented previously by Meredith (1987). Meredith suggests, for example, that AMT provides as many, if not more, benefits for SMEs than it does for large companies. These benefits include capitalising on flexibility, quality and leadtime reductions offered by the new technology. In earlier work, Meredith (1985) indicates that smaller companies are more selective in the implementation of AMT in that their investment is focused on achieving pre-defined goals such as increased quality, reduced leadtime or some other area of potential competitive advantage.

A number of critical issues associated with the implementation of technology are aided by being a small company (Meredith 1981). The members of a project team are likely to possess a broader understanding of other areas of the business which would facilitate problem identification and solution development which is not constrained to individual and isolated areas of the business. This is in contrast to the more narrow perspective which may be held by a larger company which relies on individual departments, for example data processing, to lead the implementation of new technologies. In addition, the senior management team of a small firm is likely to be closer to the project than their counterparts in a larger company. This increases the possibility of obtaining a senior management project champion to support the project.

5.2 Consultancy and small and medium sized enterprises

Where the solution of strategic problems is concerned, SMEs are found to have little expertise (Fuller 1994). This expertise is typically acquired from external interventions using consultants. However, such external intervention does not guarantee success (Soh 1992). Lees and Lees (1987) suggest that SMEs often overestimate the impact of consultant support.

A number of modes of intervention and models of consultancy were described in the previous chapter. The extent to which consultancy is described in this section is based on the issues associated with SME-consultant interventions. A description of these issues is presented in three main areas. These areas include consultant characteristics, engagement, and problems associated with SME-consultant interventions.

5.2.1 Consultant characteristics

Rynning (1992) describes a survey of 63 consulting companies and their clients. The results of this survey indicate that the characteristics of a consultant which are most important for SMEs are '*broad expertise*' and '*relevance of service*'. Rynning (1992) states that a small business '*lacks general capabilities on a permanent basis*' and requires '*result oriented practical guidance on a broad basis*'. The need for practical guidance and the lack of expertise suggests that an intervention which provides a result oriented process, and develops the client organisation would be most beneficial for small businesses. According to Rynning, the process consultation model is the most relevant intervention for developing client capabilities in SMEs. Rynning states:

'A process consultation model, which emphasises a close cooperation between client and consultant, is more applicable for small businesses.' (Rynning 1992)

The 'relevance of service' characteristic suggests that SMEs must make clear their requirements for a consultant intervention prior to the intervention. The wide range of services on offer necessitates a clear selection of an appropriate consultancy organisation offering appropriate services for the client's problem. However, the identification of requirements may be difficult if the appropriate expertise is not available.

5.2.2 Engagement

It has previously been suggested that an engagement based on the process consultation model is the most beneficial for small companies. The accumulated data from a number of consultancy organisations (Rynning 1992) in part supports this and indicates that consultants engage in problem formulation, problem solving, strategy development and implementation. A major problem exists, however, if consultants use predetermined standard approaches and solutions to rectify client problems. Fitzgerald (1991) challenges the methodological approaches used by consultants, and suggests that there is no empirical evidence supporting the use of context free standardised processes for client-consultant intervention. This view is supported by Staughton *et al* (1996) who describe the failure of consultants to provide strategic support for SMEs in the DTI's Manufacturing Planning and Implementation (MPI) initiative. Drawing from the data of 60 projects, Staughton *et al* (1996) describe the deficiency in the approach taken by consultants and state:

'The typical stance adopted by consultants was to implement solutions with little attempt to debate and agree the problem which the solution was intended to solve. The orientation was towards the application of well-practised techniques rather than matching techniques to company needs...' (Staughton *et al* 1996)

In addition to the deficient intervention used by the consultants on the MPI scheme, it is also recognised that many SMEs accepted an intervention delivering a “quick fix” and were receptive to the panaceas offered by consultants (Staughton *et al* 1996).

5.2.3 Identified problems

Interventions based on “quick fixes” and standardised solutions have been identified as problems to be overcome. The perspective of best practice as described in Chapter 3 suggests that to overcome technical fixes and the use of standard solutions it is necessary to identify the key concepts associated with a particular best practice model. This requires an intervention to support the transfer of knowledge regarding the key concepts. However, Rynning (1992) reports that the major problem in transferring knowledge to smaller firms is the client’s divided attention and busy schedule. The client is so preoccupied with the necessary day to day business activity that it is unlikely that complex conceptual models would be internalised. This indicates that a more flexible approach is needed for an intervention which supports the work pattern of the client.

A further issue constraining a successful intervention is communication. Staughton *et al* (1996) imply that the consultants involved in the MPI initiative did not take into consideration the limitations of SMEs in understanding the language, concepts and frameworks associated with strategic change. Furthermore, the consultants were engaged in ‘installation’ rather than ‘implementation’ activities and did not pay attention to behavioural issues.

5.3 Inhibitors for change within Small and Medium sized Enterprises

In order to identify further issues which may constrain the introduction of best practice in SMEs, a workshop was conducted with representatives from small and medium enterprises. The objective of the workshop was to identify the factors which tended to inhibit change in their companies. The following sections highlight both the research method used in the workshop and the results obtained.

5.3.1 Research method

The participants of the workshop were split up into groups denoted by the type of company they represented. This categorisation was based on the work by Mount *et al* (1993) and include the categories: Owner Operated, Transition to Owner-Managed, Owner-Managed, Transition to Emergent-Functional, and Functional. These categories may be recognised as representing the maturity of a company towards a functional orientation.

Functional and Emergent Functional companies were well represented at the workshop with 9 and 5 companies respectively. The categories characterised as having less of a functional nature were poorly represented. These groups were merged to form a single entity comprising: Owner Operated, Transition to Owner-Managed, and Owner managed which were represented in total by 8 companies. For simplicity this latter group will be referred to as the Owner group in the following sections.

Following a brief presentation on the concepts of business process re-engineering and business change, the representatives of the SMEs were asked; 'What are the problems associated with introducing change in your Company?'. The specific responses obtained are shown in Appendix 1.

The workgroups were asked to brainstorm and record their answers based on their own particular experiences. The groups were asked to categorise the issues identified.

5.3.2 Inter-group trends

The results from the workshop which were found to have commonalities across all participating groups may be described in terms of three main areas. These areas include knowledge sharing, skills and education, and information technology.

5.3.2.1 Knowledge sharing

Unwillingness to share knowledge was a common theme throughout all the groups. In the Owner group it was evident that the Managing Directors were unwilling to share knowledge. This inhibiting feature could be due to the threat of employees setting up rival firms. In the transition to functional group this resistance included the unwillingness to share both knowledge or resources, which may reflect an internal competitive stance. The functional group identified the power of knowledge from the employees perspective which may be related to job insecurity.

5.3.2.2 Skills and education

A lack of skills and education was indicated by all groups. The categories used to describe these issues differed between the functional and the other organisational groupings. It was evident that the functional organisations noted inadequate skills and education issues as a lack of resources, whereas the other organisational types directly related these issues to a lack of investment in people. The resource view taken by the functional companies may be a result of internal competition or inter departmental budgetary factors.

5.3.2.3 Information technology

Issues relating to information technology were found to be different in each of the organisational groupings. The owner group indirectly referred to the issues of information technology by highlighting that people were cautious in adopting modern management techniques and technologies. The transition to emergent functional group discussed technology in terms of employee awareness, skill set, and the lack of knowledge regarding the capabilities of information technology. The functional group indicated the requirement for a common IT system. The need for this system may be attributable to periodic investments and isolated improvements by functional areas.

5.3.3 Group specific issues

In addition to the common issues described in the previous sections, it was identified from the results of the workshop that a number of issues had a greater relevance to the different groups.

5.3.3.1 Owner group

The central theme of this group of companies was the influence of the Managing Director and his involvement in corporate change. The extent of this was indicated by the creation of a set of specific Managing Director issues, and the statement that '*the MD is the Company*'. The issues recorded highlighted a lack of a long-term vision and commitment to change, which may be attributable to risk factors which was also identified. These issues support the findings from the literature which regard SMEs as having a short-range management perspective.

A major barrier to change for companies of this size was the fact that Managing Directors simply did not want their company to grow too big. The reason for this 'resistance to grow' may be attributable to the threat of relinquishing control. The practices which are in place in the organisations have generally evolved since organisational conception. The strong ownership of the practices which are in place in SMEs may be the cause of a major barrier to change. Managing Directors which have 'built' their Companies are resistant to incorporate new ways of working.

There was a lack of consensus regarding the availability of financial resources to support change. Some companies indicated that the payback from investment was not a key issue. It was also indicated that a difficulty existed in investing in change, and that accounting procedures to support investments were lacking. These conflicting issues could be the result of different kinds of Managing Directors, and where in some instances 'gut feel' could initiate and support change.

Time constraints were also highlighted as a barrier to change. Given that the Managing Director needs to be involved and does not want to relinquish control, the time constraints relating to the availability of his/her time affect the change process.

5.3.3.2 Transition to emergent-functional group

This group highlighted the lack of skills and training as a major factor inhibiting change.

This deficiency related to skills in analysing and understanding current business configurations, skills to undertake potential activities which may be introduced, skills related to project management, and skills related to the use of information technology. In addition to the lack of skills for information technology a lack of knowledge and competence of IT

in terms of awareness and the capabilities presented was also indicated. This may be due to the lack of on the job training resulting from a non-educational culture. The view that *'if it ain't broke, don't fix it'* may be a reflection of this culture.

A number of 'Fear' dimensions were also noted as factors restricting change. These include fear of technology which may be due to a fear of the unknown or fear relating to job security. The fear resulting from past bad experience was also listed as a factor restricting change.

The transition to a functional orientation by these companies may cause inter-functional rivalry. Clashes of personality between functions were highlighted which may be due to 'empire building' in companies of this type.

Lack of funds and time, and the need to see immediate benefits from investments in business change and development are key issues for companies of this type.

5.3.3.3 Functional group

The functional group indicated a number of external pressures which might inhibit change. These included the customer's reaction to change such as lack of product or corporate identity, and the restrictions of business regulations relating to procedure changes (e.g. BS5750).

Convincing other members of the organisation about ideas relating to change were also noted as issues for successful change.

The unavailability of suitable resources to support change were listed which included: expertise, time, finance, and the potential need for new plant and equipment.

The *'power of persuasion'* was noted as an issue relating to change which may be the result of convincing and gaining the commitment of other internal departments and/or justification to senior management. The imposition of ideas relating to change was noted as a major inhibitor.

Technology was noted as being an initiator for change if the necessary expertise and finance were available. The main restriction identified in terms of information technology was the need for a common system. Companies of this type recognise the potential for information technology but require a greater skill base to utilise this potential.

5.3.4 Workshop conclusions

A number of issues which inhibit change in three types of organisation have been identified. The common theme in all cases was the need for more resources, better skills and expertise, together with greater knowledge. Interestingly, the knowledge bases in these companies shifted from the Managing Director in the Owner group into functional based knowledge in the cases of both Emergent-Functional and Functional company types. A different view of technology was recognised from the responses of each of the company types. In the case of the Owner companies, technology was related to modern management techniques, while in the case of Emergent-Functional organisations, it was seen as a skill and expertise. For Functional companies, the need for a common IT system was highlighted. The justification and feasibility of change was noted as a prerequisite for change in the more functional based

companies whereas change based on the Managing Directors 'gut feel' was evident in the case of the Owner group.

5.4 Conclusions

This chapter has highlighted some characteristics of SMEs and some potential inhibitors of change. The general characteristics include the lack of resources available to support change, and the inability of the majority of SMEs to deal with strategic issues. While it is recognised from practitioner observation that SMEs are gradually becoming committed to training, there appears a large deficit of expertise and an inability to support any large scale training effort. SMEs attribute this to financial and time limitations.

From the literature it is possible to hypothesise that SMEs would not be able to invest in technologies which may enable business development because of high implementation costs. The observations from practitioners, however, have indicated a large investment in some technologies (e.g. CNC machine tools). The need to focus on implementation success, and the potential benefits which may be gained, is of great importance for small firms. The employees responsible for the implementation within SMEs are more likely to possess a broader understanding of the business than their counterparts in larger companies. In addition there is a greater potential for gaining the support and sponsorship of senior management in small companies. These characteristics indicate that the potential exists for SME development using new technologies and philosophies.

The mechanisms currently available for obtaining external expertise, especially for solving strategic company problems, is via a client-consultant intervention. A process consultation model has been identified as the most relevant intervention mode for SMEs. There is

evidence to suggest that major problems have been experienced by SMEs entering into a relationship with consultants (Staughton *et al* 1996). These problems have included the use of predetermined standard solutions and “quick fixes”. However, it is also recognised that two barriers restricting the development of SMEs is their lack of available time and their divided attention for change projects.

The results of a workshop, which was undertaken to identify further inhibitors for change within SMEs have clarified many of the previous results. The general issues which need to be addressed included access to better skills and expertise, and greater knowledge. The potential for a more flexible means of training and development has been clarified. The use of computer based tools encompassing an element of knowledge transfer and training may provide a suitable mechanism for the delivery of best practice knowledge to SMEs. The design of these mechanisms is an important research issue which must take into consideration the whole plethora of context specific issues identified in this and previous chapters of this thesis.

Using the issues identified from the research, the following chapter describes the development of a framework of design features for computer based tools. Computer based tools designed using these features should provide an appropriate alternative mechanism for intervention in SMEs, and for the transfer of knowledge associated with best practice.

CHAPTER SIX - Objectives and features of prototype computer based tools

6.0 Introduction

The delivery of best practice has been described as the transfer of knowledge regarding the concepts of a particular best practice model and guidelines for its implementation. It has also been suggested that the best practice knowledge supplied by the alternative intervention mechanism should be adapted by SMEs to meet their particular requirements. The approach taken should be adaptive and not prescriptive. However, SMEs are unlikely to undertake any best practice project without a clear recognition of the benefits on offer. The transfer of knowledge needs to be embedded in a mechanism which assists SMEs to achieve specific goals.

This chapter identifies a set of objectives for the development of prototype Computer Based Tools (CBT). The objectives have been synthesised from the areas investigated in this research which include the characteristics of best practice (Chapter 3), the characteristics of the modes of intervention of existing mechanisms (Chapter 4), and information concerning the characteristics of SMEs (Chapter 5). Using these objectives and the research findings which have been accumulated a set of desirable features of CBTs are described. The experimental prototypes presented in Chapters 7 and 8 are designed and evaluated using these features.

6.1 Selection of methodological approaches

The discussion presented in Chapter 3 concluded that best practice should be associated with the contextual parameters and variables of a company. Best practice is not simply the

adoption of practice from exemplar cases, but learning from the experiences of these cases and applying the knowledge acquired to the specific company requirements.

The problem for this stage of the research is to consider how to design computer based mechanisms which are:

- appropriate for SMEs;
- transfer knowledge of best practice;
- provide guidelines for the implementation of best practice;
- help SMEs identify their problems and requirements;
- allow SMEs to adapt best practice to meet their identified requirements.

Methodologies have been used to provide a structure for large projects of this nature. The use of methodologies to facilitate the process of intervention was discussed in Chapter 4. Jayaratna (1994) indicates that a methodology should indicate the steps to be taken, describe how to perform those steps, and inform why the steps should be taken. The design of the CBT may benefit by using a similar approach to that of Jayaratna's description of a methodology by also focusing on 'what?', 'how' and 'why'.

6.2 Objectives for the computer based tools

The objectives which must be fulfilled by the proposed approach can be expressed in terms of the characteristics identified in Chapter Five.

6.2.1 Knowledge transfer

The deficit of knowledge and expertise has been identified as a factor limiting the improvement of many SMEs. The transfer of knowledge should enable the assimilation of

best practice principles in a company situation. Using a methodology to structure the intervention, the effect of this transfer should be a 'guided change' in which practices within the SME environment are improved and integrated towards an intended corporate goal. It was suggested in Chapter 5 that SMEs tend to focus on the benefits offered by a change project. In addition, SMEs have a short range management perspective (Ibrahim and Goodwin 1986), and are not prepared to invest in education and training unless it has an immediate payoff (Handy *et al* 1988). The delivery of best practice should therefore provide companies with quantifiable benefits which are immediately reflected in corporate performance, and increased competences which provide the foundation for long term development.

6.2.2 Low cost

SMEs have been identified as having a limited financial resources to support business change and development. This factor means that the delivery mechanism should not be expensive. This objective uncovers a potential problem for the research given the high costs often associated with the development of computer software. However, it has been suggested that the concepts and principles of best practice should be adapted to individual environments. A single instance of a delivery mechanism must be capable of being adapted to a large number of SMEs. If the mechanisms are applicable to a large number of SMEs then the high development costs may be counter balanced by the relatively low reproduction costs of magnetic media. This therefore indicates that the mechanism should encapsulate generic principles and frameworks which may be used by a large number of manufacturing SMEs.

6.2.3 Availability of time

A key characteristic of SMEs is the limited amount of time they have to address corporate development. The research has indicated that a major problem in transferring knowledge to SMEs is the client's divided attention and busy schedule. A key objective of a mechanism to transfer best practice should therefore be to effectively manage the participants required in the change project.

6.2.4 Deficiencies of existing mechanisms

The traditional mechanism to achieve the transfer of best practice concepts has been the use of consultants. This research has suggested that consultancy approaches for the provision of strategic support for SMEs have had disappointing results. This may be attributable to the implementation of solutions without a full appreciation of company requirements (Staughton *et al* 1996). Best practice should be adapted to meet specific company requirements and should not be prescribed.

The benefit of a CBT approach is that once the initial capital has been invested, the project may be re-run incurring only operating costs. The consultancy approach, if affordable, is a one-off event.

Other best practice delivery mechanisms such as workbooks, while affordable, do not provide the dynamics to experiment with, and explain complex concepts and principles of best practice. In addition, the epistemological orientation of a workbook based approach is that knowledge is transferred from text to learner (Brody 1991). The proposed computer based approach should facilitate learning through dynamic illustrations and experimentation.

Through the illustration of complex concepts a learning environment may be created which enables SMEs to internalise the concepts.

Other media such as video and educational television do provide the capabilities to explain complex concepts using dynamic illustrations, but are deficient in obtaining the direct involvement of the company participants. These media are typically not interactive and therefore provide little potential for experiential learning (Kolb *et al* 1984) within a specific context. Without a reasonable degree of involvement in the process, ownership and commitment to potential solutions and changes may be problematic.

The computer-based tool should therefore support the explanation of complex concepts using the dynamic capabilities provided by a computer based environment and involve the participants of the company in an interactive manner.

6.2.5 Management development

One of the key objectives of the computer-based tool should be to develop the management team. To avoid the deficiencies identified from a mechanistic adoption of practice, the management team may approach the acquisition of best practice knowledge by contextualising it and adapting it for their own specific circumstance. This approach may be more easily facilitated by the management team as they have more experience of the target environment requiring change than an external agent such as a consultant may have.

The provision of a set of tools and techniques should facilitate the process of management development. The transfer of knowledge about tools and techniques and their use potentially provides frameworks for context-specific analyses of the company's situation to

be carried out. Once awareness and practical use of the tools have been achieved, their application to other projects may also be possible. The gaining of management support to a change project may also be enhanced if an understanding of the tools, techniques and analyses which provide support for decisions about change is established.

Therefore, the proposed computer based approach should develop the skills and expertise of an SME, raise their awareness of the concepts associated with best practice, and provide tools and techniques to support practical implementation.

6.3 Summary of computer based tool objectives

From the discussion presented in the previous sections it is possible to list a set of objectives which will guide the identification of the set of features required by the CBT to facilitate effective transfer of best practice. These objectives are to:

- effectively transfer concepts and principles of best practice;
- ensure low cost and affordability of mechanism;
- efficiently manage participant time;
- overcome the deficiencies of existing mechanisms (standard solutions, static media, communication of concepts);
- facilitate management development.

6.4 Features of computer based tools

This section considers the features of a CBT that are required to meet the objectives identified. The characteristics of interventions and elements of a methodology described in

Chapter Four provide an indication of the features with may be incorporated into the design of computer based tools.

6.4.1 Role of the computer based tool

A major issue which needs to be addressed is whether the CBT will play a supporting role to a methodology or whether an entire methodology will be encapsulated within the CBT. If a supporting role is selected, the specification of the extent of that role needs careful attention. In particular, the integration between off-line human activities and on-line processing, the extent to which analyses are performed automatically, and the extent to which solutions are specified by the CBT must be well thought out. If a methodology is encapsulated within the CBT then such features as the physical interaction between company participants and machine and the management of information repositories must be considered.

6.4.2 Structure and guidance

The methodology facilitating best practice is likely to possess its own structure. This structure may be utilised to design the method of operation of the tool. An assessment of whether the structure of the delivery mechanism should use a systematic or a systemic structure needs to be addressed.

A systematic approach may provide SMEs with a manageable sequential structure with clear objectives for the process from the outset. This approach may be more suitable to the identified characteristics of SMEs including low expertise and limited time resource. The approach could guide SMEs through small manageable phases or steps with designated time scales for the accomplishment of each step.

An alternative perspective is to avoid the prescription necessary in a systematic approach and provide a systemic approach where key areas of concern are presented by the CBT. The order and degree to which each area is addressed in this case would depend on the judgement of the user. This approach may enable the selection of an individual path or process which best fits the needs of a specific SME, and may provide a mechanism for exploratory learning.

In both cases the management of the overall process may be facilitated by a guide. In the case of a systematic approach the guide may explicitly set goals, time scales, rationale of methodological activity, and assistance in analyses which may be provided in terms of examples and detailed steps of operation. The systemic approach should be able to suggest the key objectives which should be met, and the concepts which should be understood. Guidance may be provided on the potential links to other key areas of concern and to associated concepts in the best practice model.

6.4.3 Tools and techniques

To assist SMEs in the process of adapting practices to fit their environmental needs, tools and techniques may be used. It is envisaged that tools and techniques could be used in an approach to facilitate an understanding of Company requirements via the manipulation of context specific data. Tools and techniques may provide a useful way in which context specific practice may be adapted by the SMEs themselves.

The delivery of tools and techniques may be regarded as having two essential aspects. Firstly the raising of the CBT user's awareness of a particular tool or technique. This

awareness could include the rationale for using the particular technique, the process for its use, and the format of the results which should be expected.

The second aspect is concerned with the extent to which the CBT automates any analyses performed using a particular tool or technique. Although highly automated analyses may speed up the methodological process, and would overcome the problems of low expertise and busy schedules of SMEs, it is unlikely that the transfer of diagnostic skills would be as well supported. A key design decision is therefore the degree to which analyses presented in the proposed approach should be automated.

6.4.4 Decision formulation or decision support

This feature of the approach is concerned with whether or not the CBT should prescribe solutions or provide appropriate data to support decision making.

A potential problem with using the CBT to automate decision making is the degree to which SMEs would accept the decisions that are made. The control the SME has of the process, and the involvement of the participants in solution formulation, may therefore be reduced. Automated analyses and automated decision formulation may undermine the support and commitment the SME has for the process and for its resulting plan of action.

An alternative approach is for the CBT to collate the results from the analyses in the process and present the portfolio of results to the SME. Judgements on the action which need to be taken are therefore made by the participants of the process and a higher degree of commitment to the solution may be achieved.

6.4.5 Project management

To meet the specified objective of maximising the efficiency of the methodological process, and to make effective use of participant time, the CBT may incorporate a range of project management techniques. The results of the research have indicated that a major problem for intervention in SMEs is the client's divided attention and busy schedule. A schedule for the methodological process could be encapsulated in the CBT which would keep a diary of group meetings and due dates for deliverables. The specification of the required participants for each task in the process could also be supported by the CBT. The timely recommendation of tasks to be completed and the participants required to complete the tasks would increase the efficiency of the process. The efficiency of the process could also be increased by supplying data and information as required.

A possible feature of the CBT could therefore be to maximise the efficiency of the process by careful project management facilities. It is envisaged that this feature would be more applicable to the step by step systematic approach as opposed to the systemic approach discussed in Section 6.4.2.

6.4.6 Group working

A potential feature of the CBT would be the provision of group working facilities. Group work would be required to gain consensus on data used for analyses, to gain consensus on the results of the analyses, and agreeing plans for action. The key consideration of this feature of the CBT would be to address whether group work should be facilitated on-line, or off-line.

Much research has been conducted to address on-line group working. Areas such as computer supported co-operative working (CSCW) and groupware products have been reported in the literature (DTI 1995, IEE 1991). CSCW encompasses a large number of research domains which are concerned with the use of computers to support user groups (Rodden 1991). The concepts of CSCW are based on a changing perspective of information technology. DTI 1995 states:

'...The traditional view is that IT should automate existing processes. CSCW offers the opportunity to complement and enable changes to work processes and organisation.'

While on-line group working is recognised as a potential feature of the CBT, it is unlikely that SMEs would possess the technology required for implementation.

Off-line group-work may be facilitated by the CBT providing the results of analyses for each participant. In such circumstances, a meeting may be scheduled where consensus on the information supplied by the CBT would be achieved. This approach encourages discussion and debate and the collation of a range of perspectives about a particular analysis or a proposed change. An alternative off-line group working approach is to debate and gain consensus prior to the input of information to the CBT.

6.4.7 User interface

This section addresses the features of the user interface for computer based tools.

The design of the user interface for information systems is a well researched domain.

Shneiderman (1992) describes the benefits of good system and interface design:

'Effective systems generate positive feelings of success, competence, mastery and clarity in the user community. The users are not encumbered by the computer and can predict what will happen in response to each of their actions. When an interactive system is well designed, the interface almost disappears, enabling users to concentrate on their work, exploration or pleasure.'

To achieve a good design there are a number of general design issues which may be used to guide development (Shneiderman 1992). These are paraphrased from Shneiderman and include:

- identification of appropriate functionality for the user base;
- reliability of commands which are made available within the interface;
- consistency within systems - which includes action sequences, terms, units, screen layouts, colour and typography;
- consistency between systems and non-computer (paper-based) systems;
- portability to different systems with varying hardware configurations.

A large number of theoretical models and guidelines which support interface design are found in the literature, for example, Goals, Operators, Methods and Selection rules (GOMS) (Card *et al* 1983).

While there is much research regarding interface design, and many theoretical design models and frameworks to facilitate interface development, the focus of this research is not upon detailed interface issues.

The interface features required must facilitate the 'ease of use' of the tool to allow the evaluation of the CBT by practitioners. The interface issues are therefore constrained to include iconic or menu driven control, consistency within the tool and with non-computer systems, and a clear legible layout of information and data.

6.4.8 Data entry

The way in which data may be entered into the CBT is also a research issue. Sutcliffe (1988) indicates that the general objectives of data entry are to save the user work, and to constrain entry error rates. Two potential extremes for data entry include the importing of data directly, for example from spreadsheet based data repositories, and data entry via computer keyboard.

The success of keyboard based data entry is likely to depend on the design of the entry forms and the presentation of the data entry fields. To overcome this design problem, the data entry form may be based on its similarity to a form or document found in the company's environment. For example, the use of a year end sales form may provide a data entry mechanism which is sufficiently familiar to the user. An alternative approach is to specify the format of the data prior to physical data collection.

6.5 Conclusion

Using the research findings from the study of SME characteristics a set of objectives have been formulated for the proposed approach. These objectives are:

- to effectively transfer concepts and principles of best practice;
- to ensure the low cost of the mechanism;
- to efficiently manage participant time;
- to overcome the identified deficiencies and limitations of existing mechanisms;
- to facilitate management development.

It has been established that the elements of a methodology may provide the framework to facilitate best practice delivery. Using this framework and the characteristics identified from the intervention mechanism research, a set of features which could be used in the design of the proposed computer based approach have been described. These features are briefly summarised.

The role of the CBT could be either to encapsulate a process methodology and its associated elements, or it could provide support for a process methodology which is delivered using an alternative approach, for example, a workbook.

The CBT should provide the user with a structure of a process which may be worked through. This structure might be a systematic approach managed as a series of steps, or alternatively, it could provide an architecture of key areas of concern which may be explored by the CBT user. Guidance may be provided in terms of goals, timescales, rationale for activities and analyses, and assistance may be provided regarding the operation of tools and techniques within the methodology.

Tools and techniques should be embedded in the delivery mechanism to facilitate the analysis of specific company data. The use of tools and techniques could enable SMEs to identify their company's requirements, and experimentation using company data may facilitate context specific learning. A consideration for the inclusion of tools and techniques in the approach is the degree to which they automate analyses.

The CBT could provide an SME with a solution based on their company data, or may provide information to support decision making. Decision formulation is based on the

approach exemplified in prescriptive interventions. This would reduce the involvement of the company participants and may undermine the support and commitment the SME has for the resulting plan of action. Decision support is based on the approach of the process consultation model where the SMEs themselves are encouraged to generate the solution.

Project management facilities to schedule the process and to manage the human resource requirements may be incorporated into the CBT. These features may address the difficulties encountered by an SMEs divided attention and busy schedule.

It is unlikely that decisions regarding best practice would be made by an individual. Features to encourage group consensus for decision making are required. On-line conferencing facilities may be used to manage group working, however it is identified that SMEs are unlikely to possess the technology required for its implementation. The integration of on-line activities using the CBT and off-line activities for group consensus, is a design issue for the proposed approach.

It has been identified that to enable practitioners to evaluate the CBT it is necessary to have an easy to use interface. While much research is evident in this area, the focus of this research is not upon detailed interface issues. The interface issues for the purposes of the research are icon or menu driven control, consistency within the CBT and with off-line activities, and a clear legible layout of information and data.

To enable companies to manipulate their data using tools and techniques within the CBT, there is a need to identify a suitable approach for data entry. This may include the importing of data from other company systems or data entry via computer keyboard.

The design and evaluation of three different prototypes which are based on a subset of these features are described in the following chapters.

CHAPTER SEVEN - Prototype one: STRATAGEM

7.0 Introduction

This chapter describes the approach and subsequent practitioner evaluation of the first of three prototype Computer Based Tools (CBTs). The prototype described in this chapter encapsulates a methodology entitled STRATAGEM (Hughes 1989). This methodology is concerned with the formulation of manufacturing strategies, and existed in workbook format prior to this research. The approach taken in this case may therefore be described as the automation of a workbook.

The prototype CBT was developed to evaluate the feasibility of CBTs for intervention in SMEs, and to assess the transfer of best practice concepts embedded in the STRATAGEM methodology. The design approach is described using the framework of features which have been formulated (Chapter 6).

7.1 Selection of best practice

In Chapter 3 the author established that best practice should be associated with the contextual parameters and variables of a company. Best practice is not simply the adoption of practice from exemplar cases, but learning from the experiences of these cases and applying the knowledge acquired to the specific instance. To assist SMEs in the process of adapting practices to fit their needs, tools and techniques are used to support their understanding of the environment and to achieve specific project milestones. Tools and techniques provide a useful way in which context specific practice may be tailored.

A difficulty arises for many SMEs, which are characterised as having relatively limited expertise and immense restrictions on time, to address complex company wide improvement projects. The use of methodologies to structure these complex projects was described in Chapter 4.

Methodologies which encapsulate a set of tools and techniques may provide the means to help an organisation understand current and future business scenarios. In effect, tools and techniques used in this way may allow companies to consider a range of options for developing their business'. Methodologies may also provide structure and guidance to support the management of the process This approach potentially provides the advantage over prescriptive solutions and may be related to the differences between a process consultation approach and a prescriptive intervention..

The selection of best practice for the prototype was based on this criteria. STRATAGEM may be viewed as an instance of a best practice by which a manufacturing strategy is formulated.

7.2 Background

The STRATAGEM workbook provided a user-led systematic methodology which utilised proven tools and techniques to guide companies through the process of improving manufacturing. The methodology facilitates the identification of appropriate manufacturing solutions which may be translated into action plans for improvement. These plans for improvement are the result of empowering manufacturing managers to make critical decisions regarding the future of the business. In short, it ensures that the control of business improvement rests with the managers themselves (Hughes 1989). The

STRATAGEM methodology was based upon the results of a research initiative funded by the ACME Directorate of the Science and Engineering Research Council (SERC) (Hughes *et al* 1987), and has been previously reported (Maull and Hughes 1990).

7.2.1 Methodology Background

The following sections provide a brief background to the STRATAGEM methodology workbook. The sections focus on the structure of the methodology and its method of operation.

7.2.1.1 Methodological structure

The methodology is divided into five main stages. These are:

- Gaining top management commitment
- Project management scheduling
- Formal launch of the project
- Application - (major process steps)
- Close and debriefing

The first stage is concerned with gaining the commitment of top management to the project. This is undertaken via a presentation of the key concepts of the methodology. An internal facilitator is responsible for introducing the management team to the potential benefits of the project.

Stage two focuses specifically on the project management of the methodology. Start dates, participants to be involved, and the required and expected deliverables together with their

associated time scales are detailed. The project management specifications are used to apportion work to the project participants for the application stage of the project.

Stage three utilises an executive briefing to formally launch the project, and to notify potential participants that they have been invited to serve on the steering committee for the project. In addition to the informative briefing, a company's sales product families are identified. The product families are identified at this stage to provide a structure for the data collection activities in the application stage of the project. Sales product families also provide the unit of analysis for the analyses performed in the methodology.

The fourth stage, entitled Application is divided into four further steps of detail and constitutes the major aspect of the methodology. These four steps are:

- Strategic Analysis;
- Manufacturing Analysis;
- Manufacturing Strategy;
- Action Planning.

A graphical representation of this stage is shown (Fig 7.1) below.

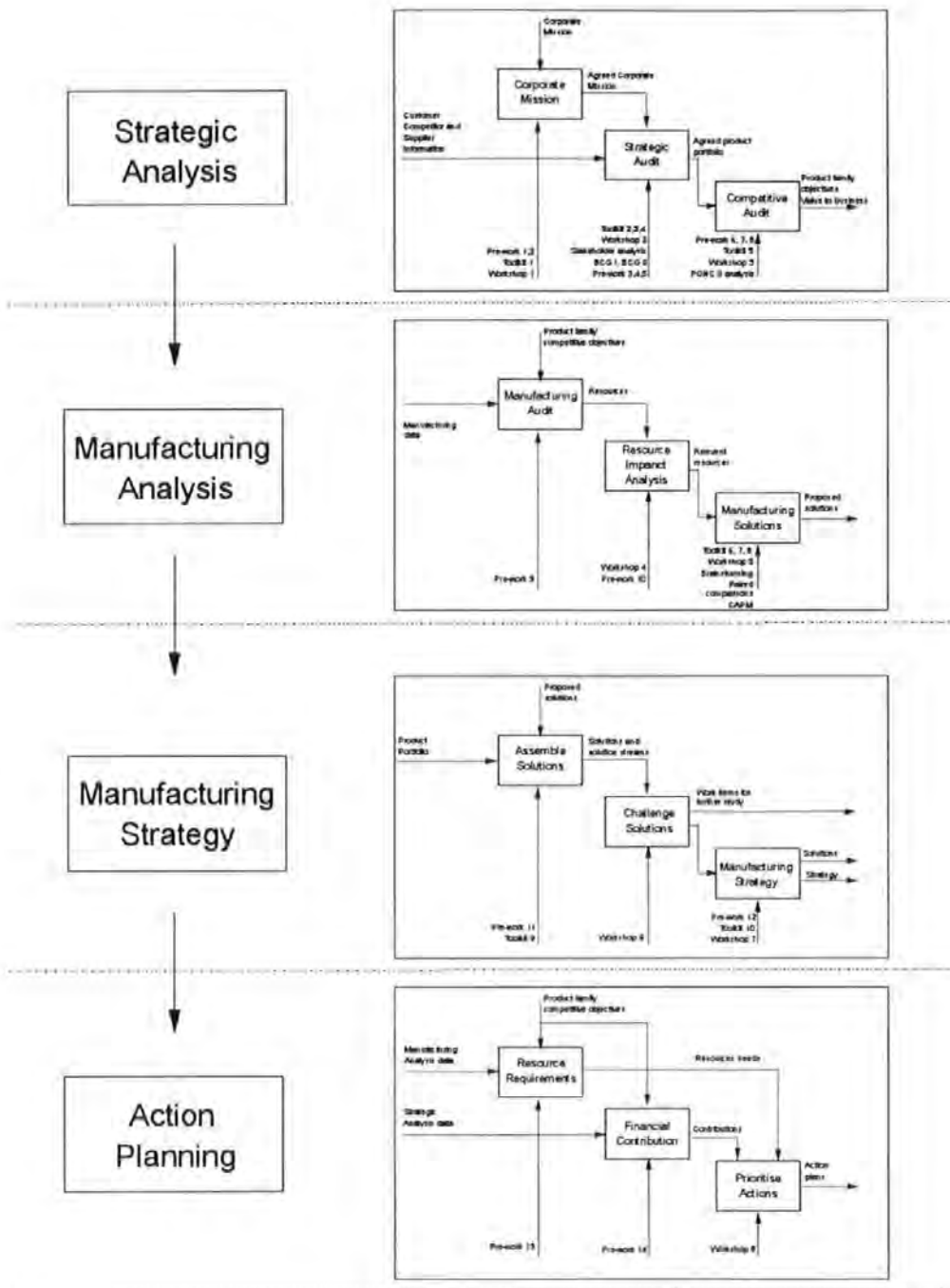


Fig. 7.1 - Detailed steps of methodology structure

The Strategic Analysis step of the Application Stage seeks to achieve the following:

- The development of a clear corporate mission statement;
- A stakeholder (customers, competitors, suppliers) analysis in the context of each sales product family;
- A contribution analysis which is used to evaluate the ability of each sales product family to generate cash flow by assessing the extent of market share and market growth;

- A product portfolio analysis to identify potential opportunities for new products by analysing potential barriers to entry and opportunities for product differentiation;
- The identification of order qualifying criteria for each sales product family;
- The identification of order winning criteria for each sales product family using the qualifying criteria identified.

The Manufacturing Analysis step of the process consists of two primary areas of activity:

- An analysis of the resources which potentially provide the greatest impact toward meeting the identified competitive dimension;
- The formulation and selection of solutions for each product family.

The output from this step in the process is the identification of the most appropriate resource and control configurations for each product family in the context of the identified competitive requirements.

The activities involved in the Manufacturing Strategy step of the methodology include:

- A holistic consideration of potential solutions and the impact they potentially have on manufacturing resources;
- A consideration of production management requirements, design, quality, resources and supplier relationships.

The Action Planning step addresses the generation of appropriate action plans for improvement. This includes:

- A consideration of the priority of each solution;

- An assessment of the extent to which each solution contributes to the intended competitive profile;
- Consideration of the direct and indirect costs of implementing the solutions.

The output of this step is a set of prioritised action plans for the company and for each functional area of the business.

The final stage in the process is entitled 'Close'. At the close of the process the prioritised action plans are presented to the board, and the facilitation team are debriefed to evaluate the process.

7.2.1.2 Operation of the process

The stages and steps of the methodology described in the previous section are managed by an internal facilitator. In addition to this facilitation role the participants in the project are required to be engaged in data collection, analytical activity and decision making. To support these participants in the application of the methodological process, workshops, pre-workshops, proformas, and toolkits are utilised.

Workshops are used primarily to obtain and generate contributions from the participants involved, to make decisions, and to agree actions through the achievement of consensus. Workshops are conducted to encourage the contributions of all involved regardless of status.

To streamline the workshop activity, pre-work activity is prescribed in advance. Pre-work activities may include the collection of data or the consolidation of a range of prior analyses.

To facilitate this activity proformas are supplied to guide the data collection and/or analytical tasks which are specified.

To support the participants conducting the required analyses, a set of toolkits are provided. Toolkits present detailed instructions on the application of particular techniques, and supply examples, rationale and systematic instructions for conducting the appropriate analyses.

7.3 Approach for the automation of the methodology

The following sections describe the approach taken to develop a prototype tool for the STRATAGEM process. The approach is described in terms of the features which were incorporated to support the structure and associated components of the STRATAGEM methodology. A summary of the set of features incorporated, and an evaluation in terms of the extent to which these features met the intended objectives are presented towards the end of this chapter. These evaluations are supported by observations made during prototype tests in SMEs and by the responses of practitioners.

7.3.1 Background research

The approach for developing the prototype began following a detailed analysis of the methodology and its components, and the identification of a suitable prototyping environment. At the time of development few software environments were available for rapid prototype development. The macro language associated with Microsoft Excel (Version 4) was selected because of the potential it presented to integrate program code (to provide the control for the methodology and tool) with screen painting and formatting facilities.

Module development and tests were conducted to experiment with the capabilities of the environment prior to CBT development. Experiments were conducted to investigate page turning (access structure), database facilities, data entry forms, dialogue box design (operation and integration to code), and the general initialising and handling of variables and arrays.

This experimental activity enabled a set of advanced capabilities to be developed in the chosen environment. These capabilities were required to facilitate rapid software development, and subsequent enhancement through each stage of the development of the prototype. The prototyping approach used for development was as described in Chapter 2.

7.3.2 Prototype development

It was originally assumed that this development would be a direct automation of the components of the workbook using the structure of the methodology. However, during development some potential inefficiencies in the original process were identified. These inefficiencies included instances of untimely data collection, and the inappropriate positioning of some activities in the process. The methodology workbook was updated in parallel as these inefficiencies emerged.

7.3.2.1 Role of the computer based tool

For experimentation purposes the role selected for the CBT was one which encapsulated the entire methodology (as described in Section 6.4.1). While the intention was to completely encapsulate the methodology it was also recognised that a large proportion of the tasks in the methodology required judgmental decisions and the gaining of consensus

from a number of participants. The design approach taken was therefore to encapsulate the methodology and to provide support and evidence for decision making.

A “programme manager” role was identified to manage the methodological process encapsulated in the CBT. This role is similar to the internal facilitation role used in the workbook based version, and involves the operation of the CBT during the application of the STRATAGEM process. It was also established that the CBT could be made accessible to other participants wishing to experiment with the tools and techniques which were encapsulated in the tool. It was envisaged that this experimentation would facilitate experiential learning (Kolb *et al* 1984) within the specific company context.

A separate ‘quick tour’ module of the CBT was developed to introduce the concepts and process of the methodology, and to further support knowledge transfer and experimentation. This approach would enable company participants to familiarise themselves with the CBT and methodology, and to explore the concepts embedded in the methodology without disrupting the live project. The transfer of knowledge together with overcoming the limitations of existing mechanisms in providing environments for dynamic experimentation was identified as an objective in this research (Chapter 6).

7.3.2.2 Integration with off-line activities

To facilitate the integration of the CBT and the off-line activities required for data collection and decision support, the programme manager was responsible for the operation of the CBT, the entry of information into the CBT, the supply of supporting documentation to other members of the process. The process by which this integration was designed is

shown in Fig. 7.2. The typical steps of operation involved with the integration of the CBT and off-line activities include:

- CBT specifies prework to be conducted by named participants prior to a workshop;
- Programme manager prints documentation stored in CBT database;
- Named participants undertake prework and pass completed proforma documentation to programme manager, or take the completed documentation to a workshop to gain consensus;
- Programme manager keys in information;
- CBT performs required analysis;
- Programme manager prints and distributes results to relevant participants.

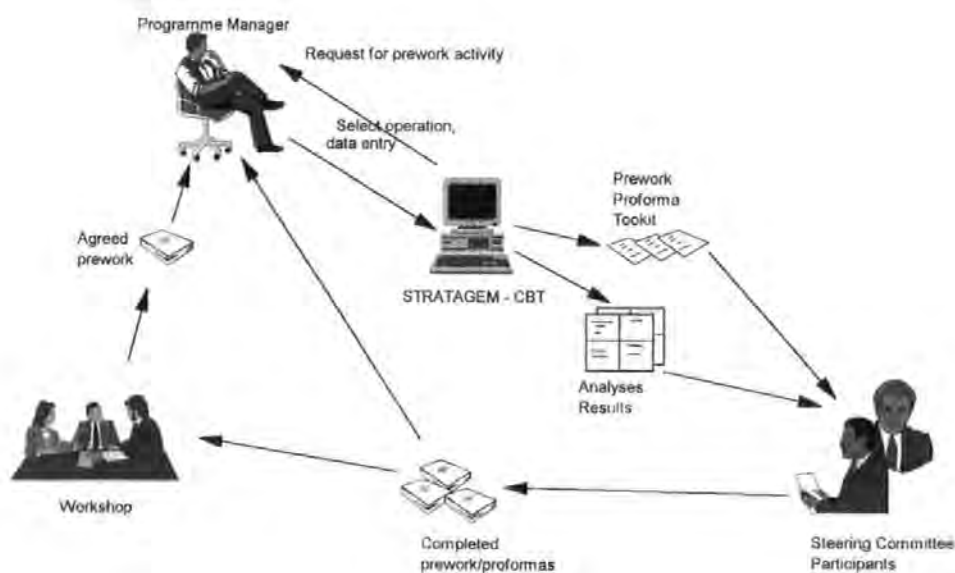


Fig 7.2 Integration of on-line and off-line activities

Analysis of the existing STRATAGEM process revealed that little or no support could be provided by the CBT to the Commitment and Contracting stages of the methodology. After

careful consideration it was concluded that the commitment to the process by top management would have to be addressed prior to the use of the CBT.

The activities which resided in the Contracting Stage of the methodology were moved to the Launch Stage. The rationale for this move was that it would be beneficial to specify dates, time scales and deliverables when the members of the steering committee were present. This change to the process facilitated its simplification to three main steps, and enforces the involvement of all participants in all decisions from the outset of the project. Involvement and simplification of the process were identified as objectives for this delivery mechanism.

7.3.2.3 User interface

The user interface was developed based on iconic 'point and click' and menu operation. This form of interface was chosen because of the lack of IT skills possessed by SMEs and an objective of the tool being its simplicity of use. Icons were supplied to initiate:

- Advancement through the methodology;
- Data entry;
- Printing facilities;
- A map of the process;
- Storage of data;
- Recording of progress made through the methodology.

The identification of appropriate screen format and colour, and ensuring the simplicity of the interface were key areas of consideration which were addressed to facilitate practitioner evaluation.

An area of the central screen was designated for the presentation of methodological and task information, in addition to housing a small context map highlighting the current stage of the methodology in relation to the entire process. The surrounding area was designated as a control and process information area which provided the title of the current step in the methodology, the methodological stage of a particular step, the number of pages (screens) in the stage and the current page being viewed. This information together with the context map were designed to minimise the danger of the user getting lost in the process. The icons were located at the bottom of the control area. Exceptions to this were the paging buttons which were situated on the left and right hand side of the control area. An annotated screen capture from the CBT highlights these design features (Fig. 7.3).

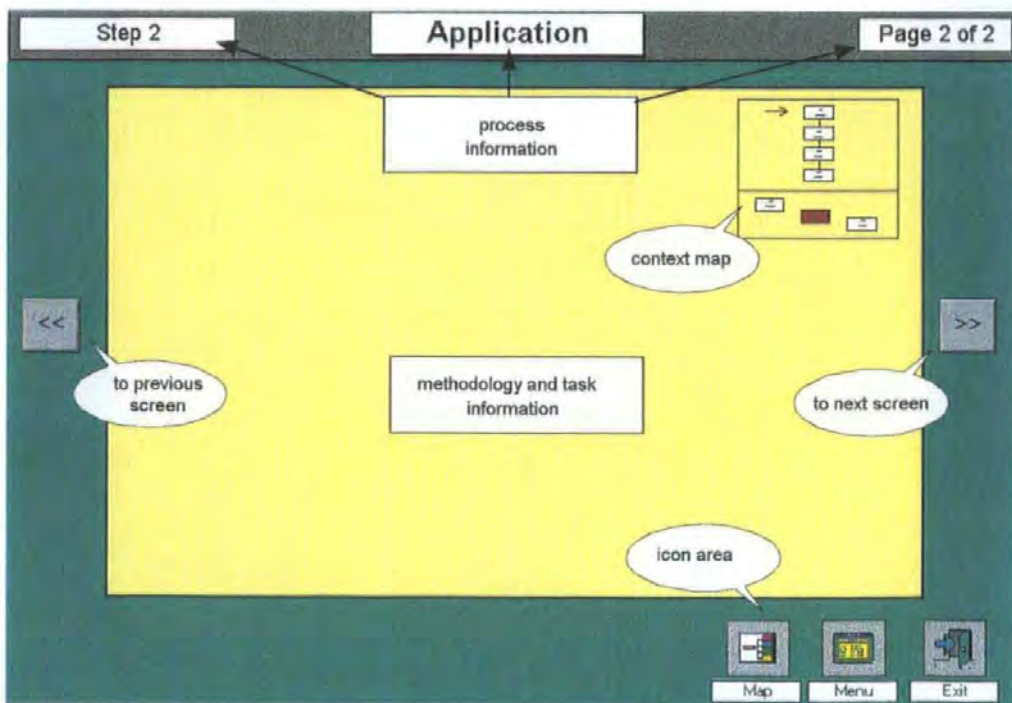


Fig 7.3 Interface layout design features

The customisation of the chosen environment enabled the user interface to appear similar to that found in completed stand-alone application software. This customisation included the

development of a set of pull down menu items dedicated to the STRATAGEM methodology. These menu items were included to follow the standard of application programs with which the target audience may be familiar. This form of inter-program standardisation was designed to reduce the time required for interface familiarisation and operation.

The user interface was designed to support a guided step-by-step operation of the tool, in addition to facilities to access any specific methodological step directly. Guided operation was identified as a potential feature of the tool (Section 6.4.2) and provides an intervention approach which capitalises on the features of a process consultation model (Schien 1987) (Chapter 4). An additional feature incorporated to meet this objective was the utilisation of the methodology structure for the design of the access structure and operation of the tool. The systematic nature of the methodology was reflected in the operation of the tool by the step-by-step advancement using the paging buttons.

The key phases of the application stage of the methodology were represented graphically in the workbook. This representation was presented in Section 7.2.1.1, and was incorporated into the design of the CBT interface. The graphical representations provided the 'gateway' to access each step in the Application Stage of the methodology, and provided a structure where the user could access the detail tasks of the methodology. The use of these graphical representations in the interface may be seen in Fig. 7.4.

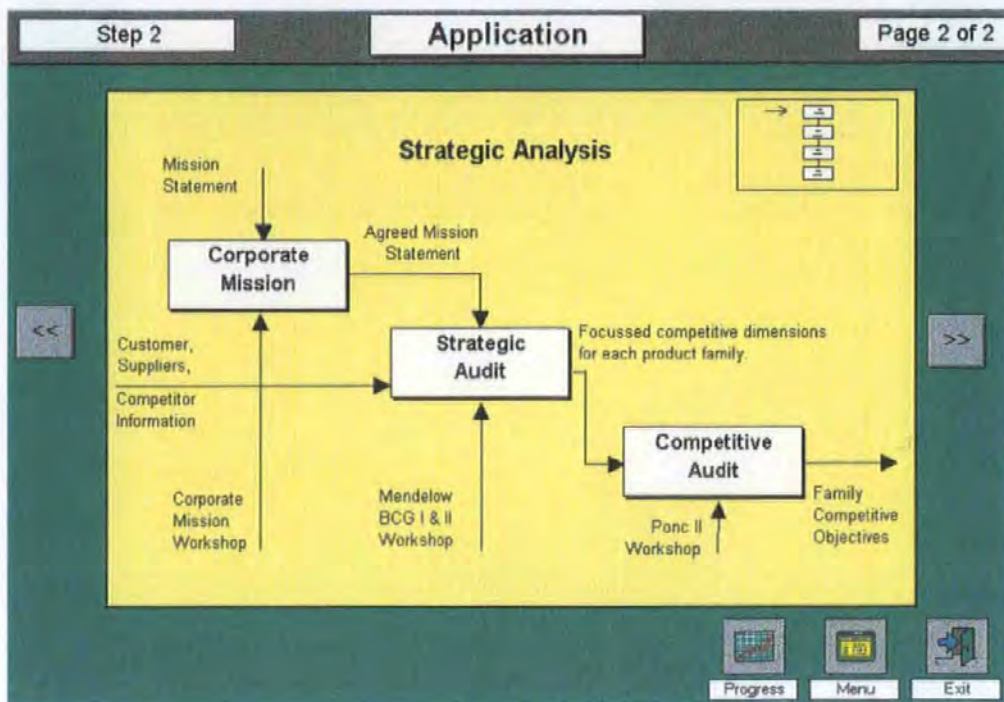


Fig 7.4 Access mechanisms to methodology task detail

7.3.2.4 Supply of supporting documentation

It was shown in Section 7.3.2.2 that the responsibility of the programme manager is to provide the supporting documentation to the participants in the process. Managing this distribution of documentation would require a full understanding of the off-line activities and the appropriate participants required to conduct each activity. This would potentially introduce complexity to the management activities of the process. The limited expertise of SMEs identified in the research (Section 5.1.1) necessitates a reduction in complexity. The knowledge required to manage the correlation between the participants and the off-line activity was embedded within the CBT. Thus, the operation of the CBT to distribute documentation would be reduced to the selection of the print icon from the user interface at the appropriate screen (stage) in the CBT. This operation was coupled with the printing of a header sheet which specified who the documentation was for, and the date by which responses were required. These characteristics were included to address the required project management features identified in Section 6.4.5.

7.3.2.5 Entry and storage of information

A key issue which had to be addressed by the CBT was the means by which company data was entered, stored, and retrieved from the system.

Data entry was facilitated via the provision of on-screen proformas which duplicated the physical proforma distributed to participants. The rationale for the design of this data entry mechanism was based on the feature of simplifying data entry activity for the Program Manager. An example of the on-screen proforma is shown (Fig. 7.5).

The data entered onto the proforma was stored in a database within the CBT.

The retrieval of this information is required to fulfil the requirements of the automated analyses. This retrieval is conducted automatically when a particular analysis is initiated.

Phase 1 Task 2 **Stakeholder Analysis** Page 2 of 2

Product Family STRATAGEM Customer Small Engineering Ltd

Enter the results of the three questions given below:
using a scale of 0 - 5.

Question 1: Is the information you have about your customers inadequate for your decision making?

Question 2: Are you unable to predict how customers will react or be affected by your decisions?

Question 3: What is the probability of your customers affecting your ability to function as a business unit?

Click **Save** to store your entered information

Save Map Menu Exit

Fig. 7.5 On-line proforma

7.3.2.6 Analyses

To enable the simplification of the process and the reduction of complexity for the user, the provision of automated analyses was investigated. These analyses relied on the retrieval of information stored in the database within the prototype. In addition to this data, many of the analyses required additional input from the user to specify the specific dimension of data which would be used. These dimensions included, for example, the identification of a specific sales product family or stakeholder (customer, competitor or supplier) information. To facilitate the capture of this information a set of dialogue boxes was designed. Where possible the dialogue boxes contained default settings which were retrieved from the database. An example of a dialogue is shown (Fig 7.6) below. The product family dialogue contains company specific product family information which was entered and stored at the beginning of the STRATAGEM process.

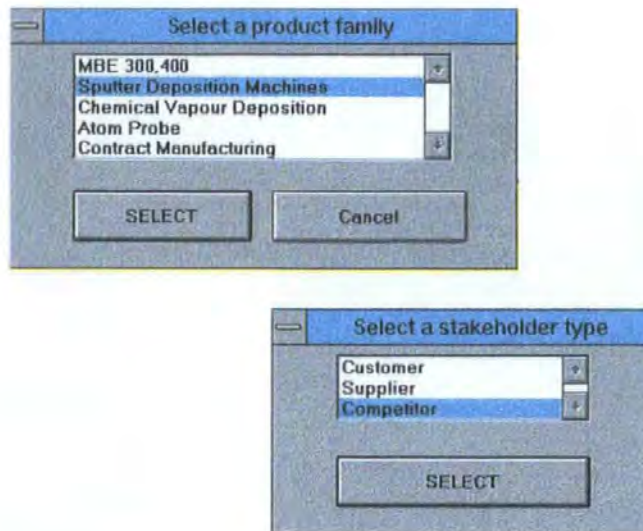


Fig. 7.6 Example dialogue

Many of the analyses found in the STRATAGEM workbook were automated in the CBT. It was envisaged that this approach would improve the efficiency of the methodology, and facilitate the generation of consistent results. A potential negative aspect of this automation

is the reduction in practical experience. However, by experimenting with the results supplied and manipulating the data a degree of experiential learning may be achieved. Experiments may be conducted using the tool to experience the effect that changes to values have on the analysis results presented by the tool. This form of simulation, while relatively primitive, is conducive to the transfer of contextually specific knowledge identified in the objectives of this research. An example of the results of the computer generated analyses which were embedded in the prototype is shown below (Fig 7.7)

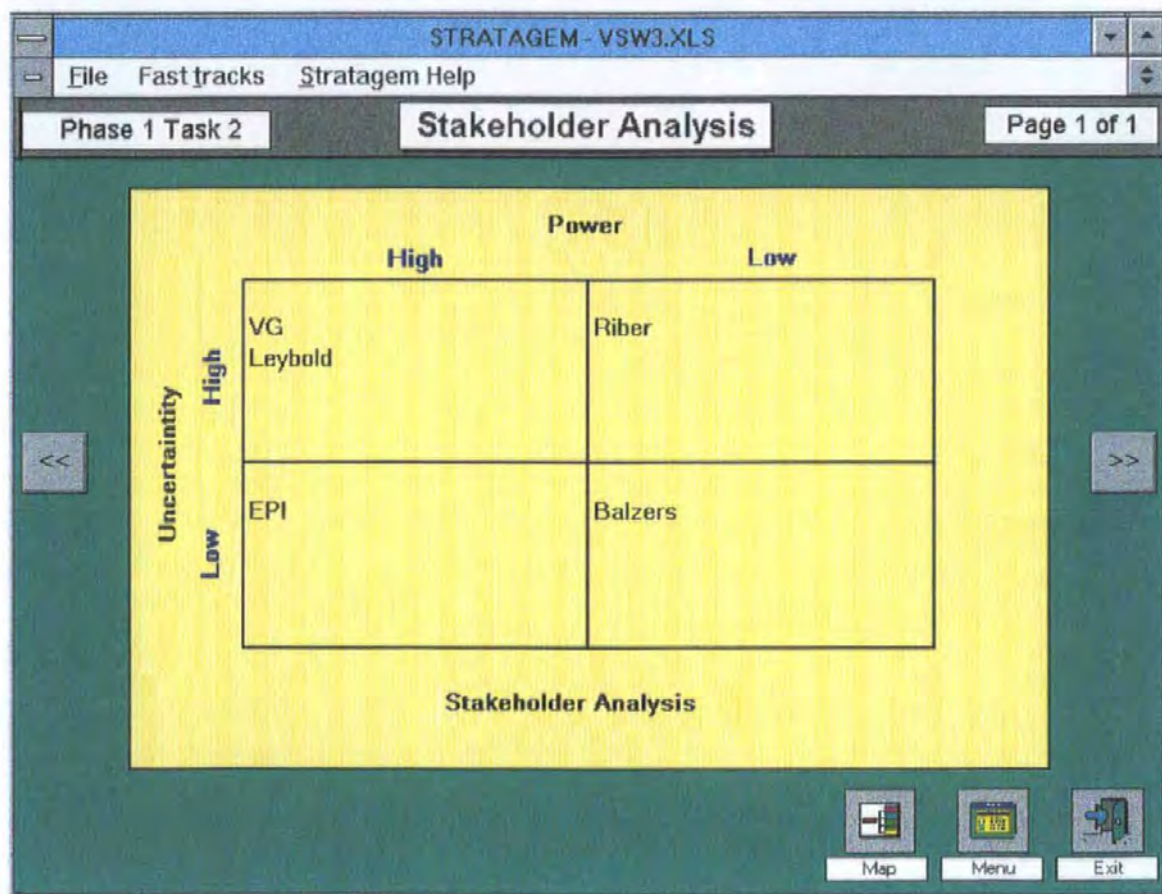


Fig. 7.7 Computer generated analysis

These analysis results represent the key competitors to the 'MBE 300,400' product family of one of the evaluation companies.

The CBT assigns each stakeholder to a quadrant of the stakeholder grid based on the values specified on the proforma. In the instance where more than one stakeholder exists in a

quadrant, further sorting is conducted to present the stakeholders in descending order of importance. For example, in the high power, high uncertainty quadrant 'VG' is presented as having a higher uncertainty than 'Leybold'. This sorting operation was only implemented for the uncertainty dimension for this analysis.

The results of analyses are added to the set of stored documentation automatically by the CBT. These results may be printed and distributed by the Programme Manager when they are required in the process.

Each analysis conducted by the CBT was designed based on the generation of graphical representations. The representations used frameworks, graphs and charts to promote a greater understanding of the results by the participants in the programme. If a greater understanding of the results could be achieved it is likely that the results would be more useful in making judgmental decisions. In addition, the representations presented provide a common language to all participants to enable debate and the gaining of consensus.

7.3.2.7 Project management

A set of project management features was included in the CBT prototype in an attempt to meet the objectives of maximising the efficiency of the process and the careful utilisation of human resources. The features identified to meet this objective included the provision of a progress schedule and process diary, and the specification of the required participants for each task in the methodology.

The diary feature was implemented in the tool by enforcing the entry of expected times and dates of future workshops in the process. These dates and times were inserted onto the

header sheets attached to the documentation that would be distributed to the participants. Pre-work which was required for a workshop could therefore be completed in relation to the time and date information specified on the header sheet.

An additional feature which was incorporated into the CBT was the use of a progress chart. This chart provided a means by which the Programme Manager could track the completion and receipt of documents which formed pre-requisites to subsequent stages. The operation of this progress sheet was further enforced by restricting access to future stages until the pre-requisite documentation had been acknowledged in the progress facility.

To meet the objective of careful utilisation of human resource the CBT was designed to print only the relevant documentation for the relevant participants. This was achieved by explicitly naming the individuals who were regarded as having responsibility for off-line activity on the documentation output from the tool. The assignment of relevant human resource was managed automatically by the CBT.

7.3.2.8 Quick tour

The design and implementation of a 'Quick Tour' in the CBT was provided to enable participant familiarisation with the tool and process, and to provide an explanation of the techniques encapsulated. These explanations were designed to support the transfer of knowledge which would serve as a foundation for the experiential learning which could be obtained during the operation of the tool. The rationale for the Quick Tour was the provision of an overview of the overall methodological process. A degree of familiarisation by participants involved in the process prior to its actual operation could aid its effective and efficient operation. The design of the quick tour interface was a direct representation of

that found in the main CBT process. A consistent interface for both the Quick Tour and actual process would facilitate experiential learning in the operation of the tool.

7.3.3 Summary of prototype features

A description has been provided of the main design features used in the development of prototype one. Using the basic structure of features presented in Chapter 6, a summary of the features incorporated into prototype one is shown (Table 7.1).

Features of CBT - prototype 1
Role of CBT: The entire stratagem methodology was encapsulated within the CBT
Structure and guidance: The prototype was designed using the systematic structure of the methodology. Structured guidance was facilitated by the provision of 'previous' and 'next' operations and by information regarding the next stages and steps in the process.
Tools and techniques: A separate 'Quicktour' module was included to allow the transfer of knowledge regarding the overall process and the tools and techniques within the process. The analyses conducted by the tool in the main application modules were automated.
Decision formulation and decision support: The automated analyses in the CBT were designed to provide analytical support for decision making of company participants.
Project management: A number of modules were included in the design approach to assist project management activities. A progress schedule was included to track the accomplishment of each stage and its components. A process diary was implemented to manage the workshops and meetings required for decision making and consensus. Off-line data collection and pre-work activity were specified to relevant individuals only.
Group working: Group working was managed off-line, with consensus and decision making after computer generated analyses.
Interface: The interface layout was designed using specific areas for user control and for the information presented. Iconic and menu facilities were designed for interface control by novice users. Interface consistency was maintained throughout the CBT, and with the off-line documentation.
Data entry: Data collection was scheduled by the CBT. Entry forms were designed which duplicated the off-line documentation.

Table 7.1 - Summary of features for prototype one

7.4 Prototype tests

To facilitate prototype enhancement and revision the CBT was demonstrated to a number of companies. In addition to the practitioner involvement during the iterative development stages of the prototype, an in depth evaluation of the final prototype version was conducted by two manufacturing SMEs. Observations were made during the use of the CBT by the companies. These observations provided insight into the feasibility of the proposed approach and of the design features incorporated. The responses from the practitioners involved in this evaluation are commercial in confidence. The results are described while maintaining their anonymity.

7.4.1 Company A

Company A is a small manufacturing company. The Company employs 50 people and is involved in the design, manufacture and installation of catering equipment for the hotel and restaurant industries. At the time of prototype evaluation the Company was actively seeking opportunities for increasing sales revenue and reducing its cost base to improve profitability.

The prototype evaluation was undertaken by the MD. Before the test, meetings were held at the Company to explain the research project and to introduce the rationale and structure of the methodology. Consequently, the MD possessed some knowledge of the methodology prior to evaluating the CBT.

In addition to the results presented below (Table 7.2), issues relating to the content of the methodology were indicated. For example, no representation of Research and Development personnel had been provided on the steering committee participant list within the CBT.

Evaluation of CBT - Company A
Role of CBT: No specific comments were provided
Structure and guidance: The structure and guidance of the prototype was sufficiently simple to allow the comprehension of the logical progression of the methodology. The approach and structure used was " <i>reasonable for a small manufacturing enterprise</i> ". No problems were encountered in the progression through the methodology.
Tools and techniques: The use of tools and techniques within the CBT were regarded as useful for generating pertinent information for decision making. The tools and techniques were found to be relatively easy to use. The separate quick tour module was evaluated as useful for introducing the methodology process and components, but it was highlighted that sufficient detail for training purposes was not provided.
Decision formulation and decision support: The support provided for decision making was found to be useful. It was identified that the results provided for decision making would stimulate discussion.
Project management: The project management techniques embedded within the CBT were found to be useful for managing progress through the methodology. The process diary was regarded as a useful tool to help keep the project on schedule. Explicit reference was made to the inability of the tool to manage the re-scheduling of dates and times. The careful use of required human resources was noted as an important feature of the tool.
Group working: The process which integrated the on-line activities and the off-line discussion was considered a useful approach for SMEs. It was identified that the off-line workshops with defined objectives were useful for gaining consensus.
Interface: A number of issues were raised regarding deficiencies of the user interface. Problems with navigation were encountered when accessing the detailed tasks of the application stage. This raised issues regarding the consistency of the navigational features of the tool. The use of the mouse pointing device was not restricted to the left button allowing access to the underlying application software using the right mouse button. Similarly areas of the interface not designated for specific operation were not protected allowing access to the underlying Excel worksheet. The general layout and use of colour within the interface was regarded as clear and consistent.
Data entry: The data entry mechanism was regarded as suitable, but it was suggested that the questions on the proformas were difficult to understand.

Table 7.2 - Evaluation results from Company A

The methodology and CBT was regarded by the MD of Company A as a suitable

intervention mechanism for company development and improvement. It was indicated that

the structure and management enforced by the CBT was a useful approach. The introduction of a number of tools and techniques which were previously unknown, were found to be useful for analysing company data. The results of the analyses stimulated thinking within the project team about ways to improve the operations of the Company.

7.4.2 Company B

Company B is a small manufacturer of electric and hydraulic winches for the automotive industry. The Company's operations involve the design of new product and processes as well as the traditional manufacturing activities. At the time of evaluation the Company employed 60 staff after two waves of redundancy. To overcome their difficulties at that time, the management team recognised that they needed to react to external pressure by addressing their strategy and competitive profiles.

As in the case of Company A a number of meetings were held with the management team to introduce the methodology and discuss the potential benefits of undertaking a project using the CBT. The evaluation was undertaken by the manufacturing manager. It was recognised that an evaluation by a manufacturing specialist would provide an additional test of the tool's appropriateness for small manufacturing companies.

In addition to the results of the evaluation (Table 7.3), a more general problem concerning the feasibility of CBTs for company intervention and support was indicated. The availability of appropriate equipment to run the software was identified as a potential problem for small companies. Company B possessed a limited number of low specification computers with monochrome displays. While this is identified as a problem at this test site, the continuing price reductions of computer hardware and the high cost of consultant support indicated

that the purchase of the appropriate equipment, and the capital that would be expended, made the CBT a feasible option.

Evaluation of CBT - Company B
Role of CBT: No specific comments were provided
Structure and guidance: The implementation of the methodology using the CBT was regarded as controlled and structured. The manufacturing manager was able to follow the process using the guidance offered by the CBT.
Tools and techniques: The use of tools and techniques to automate the analyses within the CBT was felt to be an important feature that reduced the burden of performing the analyses by manual methods. The quick tour module was recognised as a good introductory and preliminary exercise to the CBT but it was felt that more detail was required if it was to be used for training purposes.
Decision formulation and decision support: It was felt that it was important that the CBT did not prescribe solutions or determine actions to be taken in the company. The supportive role of the CBT for decision making was regarded as a useful approach.
Project management: The project management features which were recognised as important were the progress scheduling, and the efficient management of participant time. The feature relating to the explicit addressing of hard copies to relevant individuals was identified as a key requirement.
Group working: The ability to print hard copies of information, proformas, results and other associated components was regarded as an essential aspect of the CBT approach. The integration between on-line and off-line activity was regarded as a good approach.
Interface: Generally, the interface was evaluated as being easy to control using the icons and menu, and the screen designs were considered to be clear. It was indicated however, that a small amount of practice and familiarisation was required. As in the case of Company A some difficulty was found with the navigation to the detailed tasks in the Application stage of the methodology. This indicated that the consistency of the operation of the CBT needed to be maintained.
Data entry: The data entry features of the CBT were regarded as simplistic, with explicit reference being made to the hard copy and data entry screen consistency. The collection of only the data which was required by the process i.e. cost data when cost reduction was selected was thought to be an efficient approach.

Table 7.3 - Evaluation results from Company B

The Company believed that the methodology and CBT would be applicable for their current competitive situation. The highly structured approach presented was regarded as useful to support strategic thinking. It was suggested that the tools and techniques enabled the Company to learn about themselves. A request for a completed version of the CBT suggested that the intervention approach was appropriate.

7.5 Conclusions

This chapter has described the approach taken and the features incorporated into the first of three prototype CBTs. The purpose of this development was to investigate the applicability of using CBTs as intervention mechanisms for SMEs, and for the transfer of best practice knowledge. Results were obtained via in-depth practitioner evaluations of the CBT and underlying methodology.

Both companies indicated that the CBT was a useful and applicable mechanism for company intervention.

Similar results were obtained from the companies regarding the design features used. The results suggest that a highly structured and carefully managed process are essential SME requirements for this kind of intervention mechanism. The tools and techniques embedded within the CBT enabled a degree of context specific learning. The partitioning of the on-line managed process and the off-line consensus building and decision making is identified as a good design approach for SMEs. No indication was made regarding alternative roles for the CBT during the tests.

The following chapter describes the development and testing of a second prototype to extend the research. The chapter describes the use of a CBT to support a workbook based methodology.

CHAPTER EIGHT - Prototype Two: PROFIT

8.0 Introduction

The previous chapter described the development and testing of a CBT which encapsulated a methodology. This chapter extends the research by investigating the use of a CBT to support a process methodology. The objective of this part of the research is to establish the applicability of the approach for intervention in small manufacturing companies, and for the delivery of concepts associated with best practice. The aim of the research was to obtain a greater understanding of the approach and features which should be incorporated into a computer based tool to deliver best practice to SMEs.

The research and development of prototype two builds upon a previous Department of Trade and Industry (DTI) project entitled FINJUST. The FINJUST project involved the development of both a methodology and a CBT for the cost justification of investments in Computer Integrated Manufacturing (CIM). During the fifteen month period of the project the author was invited to conduct a critical evaluation of the CBT. Larsen (1994) conducted a critical evaluation of the methodology, and developed a new approach. This approach was entitled the PROgram for Financing Integrated Technologies (PROFIT). The author's role in this project was the development of a supporting CBT for PROFIT.

An outline of the PROFIT methodology is presented to provide the background necessary to understand the issues associated with the development of the supporting CBT. In addition to the difference in application area from prototype one, a number of different features were included in this prototype. A description of these features is presented using the framework described in Chapter 6. Following a summary of the design features of the

prototype, the results of practitioner evaluations are presented. The chapter concludes by highlighting the success of the approach and the design features used.

8.1 Methodology background

Following the structure of the previous chapter a brief description of the methodology which the CBT was intended to support is described. The purpose of this description is informative and is based on the description by Larsen (1994).

The PROFIT methodology was designed to assist SMEs in the evaluation and cost justification of Advanced Manufacturing Technologies (AMT). The methodology involves financial modelling as a method to identify the needs of a business, and to justify potential investment. This is achieved via the use of a profit and loss sheet to present information regarding a Company's financial status. The profit and loss sheet is used to illustrate what the effects of external influences, such as inflation, would have if no investment and no business development was undertaken, and to indicate the potential benefits expected from financial investment in AMT. While the use of the profit and loss sheet is central to the methodology, systematic guidance is supplied by a workbook.

PROFIT is an example of a best practice for considering the implications of the introduction of AMT. It was identified in Chapter 3 (Section 3.2.3.1) that while technologies provide the mechanisms for the development of best practice, the greatest benefit is in understanding the implications associated with the implementation of the technology.

8.1.1 Methodology structure

The PROFIT methodology consists of four main stages which include Launch, Financial Modelling, Evaluate Options, and Financial Justification.

The Launch Stage is concerned with briefing the prospective users of the workbook and CBT about the concepts and process of the methodology. This stage is also used to identify the appropriate sales product families that form the units for financial analysis and projection.

The Financial Modelling Stage involves the collection of revenue and cost data for each sales product family. The profit and loss sheet is used to create a model of the current financial operating status of each sales product family and indicates the company net profit and loss and Return On Sales (ROS) percentage. Once a model of the current operating structure of the business has been achieved, an assessment is made regarding the '*Cost of Doing Nothing (CDN)*' (Larsen 1994). This assessment takes into account external influences which affect the operating accounts of the business.

The third stage of the methodology, Evaluation, consists of three main options. The first option is concerned with assisting a company in identifying its business needs. To accomplish this requirement a large degree of experimentation is required. For example, the affect of minimising the cost factors of one sales product family and the maximisation of the revenue factors of another sales product family can inform a company of the affect on profitability and ROS. This mechanism can be used to help identify the needs of the business.

The second option is used to assist a company in identifying appropriate investments available to address the business needs identified. This includes the identification of appropriate technologies.

The final option, option three, is used where a company wishes to evaluate business proposals. Proposals are evaluated when the business need and potential technologies for change is known. This option involves the gaining of consensus on an appropriate proposal to be financially justified.

The final stage in the methodology, Financial Justification, uses the profit and loss account to assess the effect a proposal has on the operating accounts of the business and on ROS. Using the profit and loss sheet to support decision making, a proposal may be accepted or rejected. Iteration between stage three and four is used where proposals are rejected and where new investments are considered.

8.1.2 Operation of the process

The components used in the PROFIT process are similar to those described in Chapter 7 for prototype one. Proformas, toolkits, and workshops are used to facilitate data collection, to assist participants in carrying out data collection and analytical activity, and to provide support for consensus building and decision making.

The structure and operation of the methodology is different to that used in prototype one. The mechanism used to guide participants through the methodology's structure is a workbook. The following sections describe the development of a CBT to support this workbook.

8.2 Approach for the support of the methodology

The PROFIT CBT was developed in parallel with the development of the methodology. The development of the CBT was recognised as both a constraining and enabling technology which influenced the development of the methodology.

The expertise obtained from the development of prototype one influenced the selection of the prototyping environment. In addition to this expertise, the financial modelling required by the methodology, and the capabilities presented by spreadsheet applications to specify and link complex sets of formula, supported the use of a spreadsheet based prototyping environment. As in the case of prototype one, Microsoft Excel version 4 was used to develop the prototype CBT.

8.2.1 Role of the computer based tool

The process and structure of the methodology and the management of human resources were not a concern for this prototype, as they were dealt with by the workbook. The objective of the CBT was to provide support for the complicated analyses and financial projections which were required to support decision making, to identify business needs and to analyse and select AMT to meet those needs. In addition, it was envisaged that the tool could facilitate experiential learning by allowing SMEs to manipulate the variables in the financial model. This process could inform the user of the improvements to be gained from developing particular areas of the business. The CBT would indicate potential technologies which could facilitate business development. In addition, the tool would be used to transfer knowledge regarding the potential benefits associated with a number of technologies. This approach meets the requirements of best practice delivery established in Chapter 3.

It was identified that practitioner evaluation could indicate the feasibility of the use of CBTs as a supporting technology for company intervention and the transfer of concepts via experiential learning.

8.2.2 Interface

The user interface was designed using a similar approach to prototype one. The feedback gained from the evaluations of prototype one were used to enhance the operability of the PROFIT CBT. The control of the CBT was based on an iconic design. A particular emphasis was placed on maintaining the consistency of both the operation and presentation of the control icons.

The screen layout of the interface was a difficult design problem given the amount of information which had to be displayed in the profit and loss model. The design used to display the profit and loss information for the financial model was based on a ledger book. It was postulated that the users of the CBT may be familiar with accounts held in ledger books and that the representation of the financial model using this format may be more acceptable to the prospective companies.

As in the case of prototype one, the interface of this CBT was designed by specifying two distinct screen areas. These areas may be classified as information and control areas. The diagram (Fig 8.1) illustrates the user interface using an annotated financial modelling screen, and highlights the information and control areas of the prototype's interface.

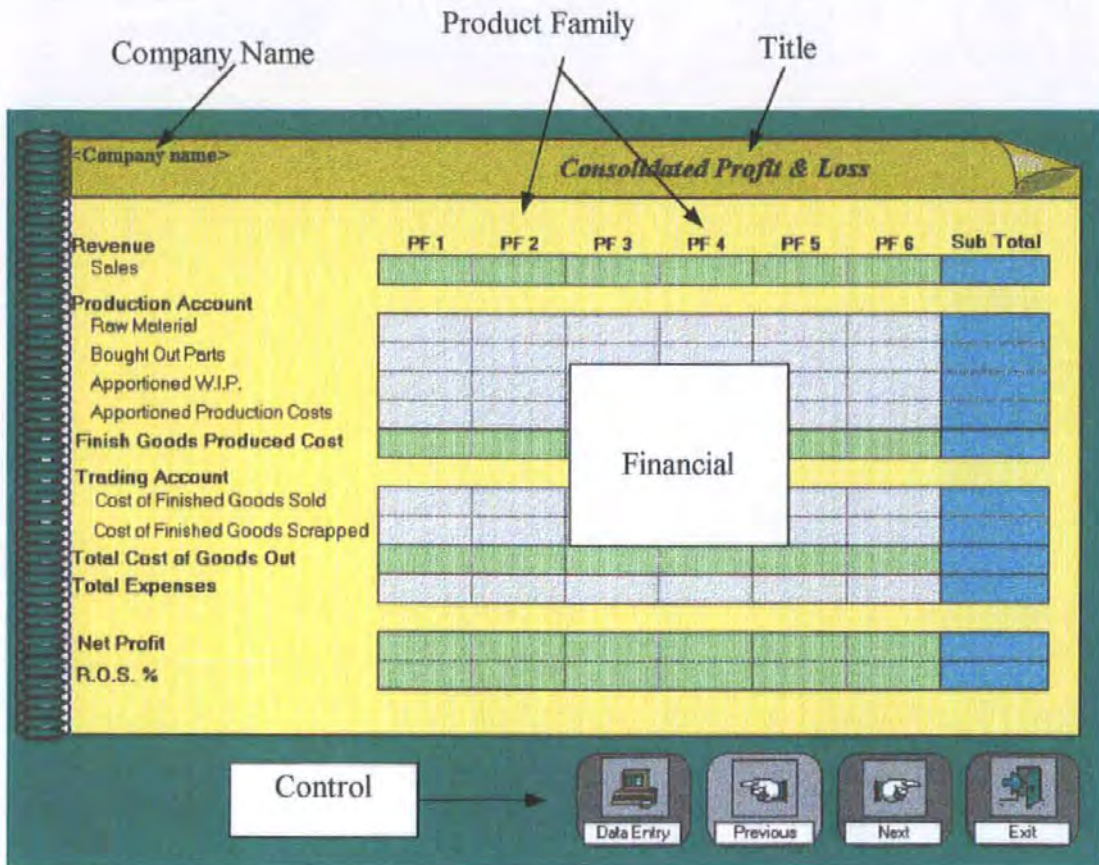
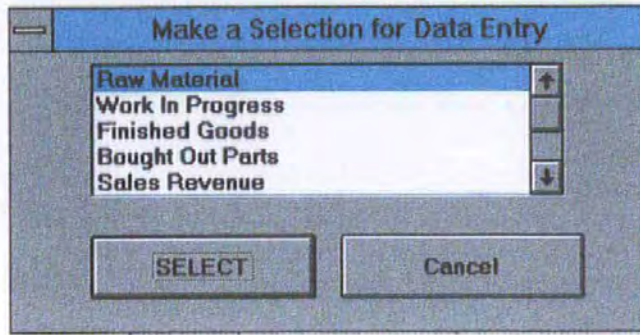


Fig 8.1 - Interface Design Features

The general control icons used to proceed through the CBT, to step backwards, and to exit the CBT, were kept in the same position in the control area on all interface screens. If a particular operation was not available, the control icon was disabled. For example, it can be seen in Fig. 8.1 that the control icon for accessing the previous screen is disabled. This design feature was incorporated into prototype two to address the inconsistencies of control which were indicated during the evaluations of prototype one.

8.2.3 Data entry

The profit and loss screen described above does not permit the entry of data directly into the model. Data entry was facilitated by a set of separate screens which could be accessed from the profit and loss model.



University of Plymouth *Raw Material Costs*

	PF1	PF2	PF3	PF4	PF5	PF6	SubTotals
Raw Materials							
Opening Stock							45
Purchases							235
Closing Stock							20
Cost of Raw Material Used							260
Cost of Goods Produced							
Volume Produced	2	10	34	60			106
Estimated Cost / unit	9.00	2.00	2.00	2.00			
Estimated Scrap / unit (%)	5.00						
Estimated Total Cost	18.90	20.00	68.00	120.00	0.00	0.00	226.90
Actual Adjusted Cost	19.52	23.12	78.62	138.74	0.00	0.00	260.00








Fig. 8.2 - Example of Data Entry Process

Following the selection of the data entry icon, the user is presented with a dialogue box where the appropriate component of the profit and loss sheet can be selected. For example, the user may select raw materials, revenue, or work in progress. A data entry screen is

provided for each component of the profit and loss sheet. An example of the handling of data entry is presented in Fig. 8.2.

An additional design feature which was incorporated in to the data entry operations of the CBT was to colour-code the information on the data entry and profit and loss sheets. White areas on the data entry forms were designated for data entry, green areas to indicate totals and sub-totals for each sales product family, and blue areas to indicate totals and sub-totals across all product families. The results of data entry for a particular component are immediately reflected in the profit and loss model. The provision of separate data entry screens facilitated the capture of detailed information for each profit and loss component. This information was used by the formulae developed by Larsen (1994) which calculated the values for the financial model and projections.

8.2.4 Tools and techniques

To support the experimentation required to identify business needs, a tool was developed to automatically project the effect that changes to the financial variables had on ROS and profitability. This feature provided the opportunity for the SME to set maximum and minimum constraints on a specific component of the profit and loss model, or to specify target values for a given component. An illustration of the projection of the sales volume operating variables is shown (Fig. 8.3), and the results of this projection (Fig. 8.4).

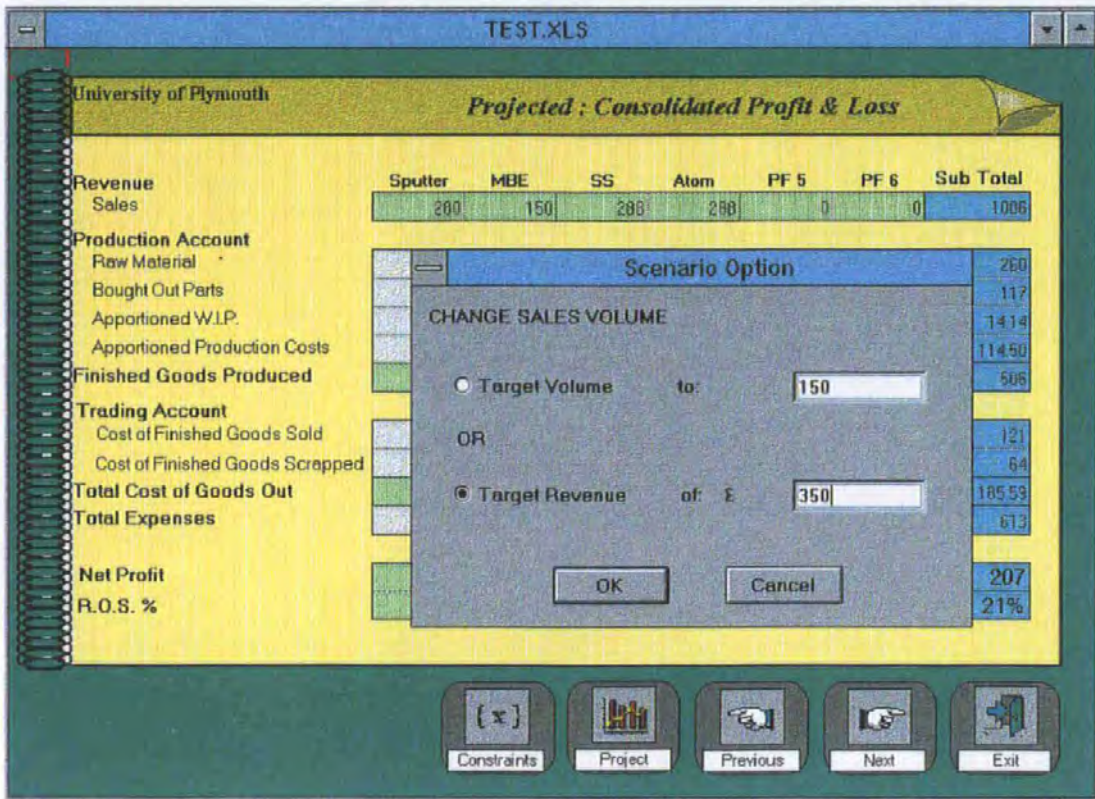


Fig. 8.3 - Projection of Operating Variables

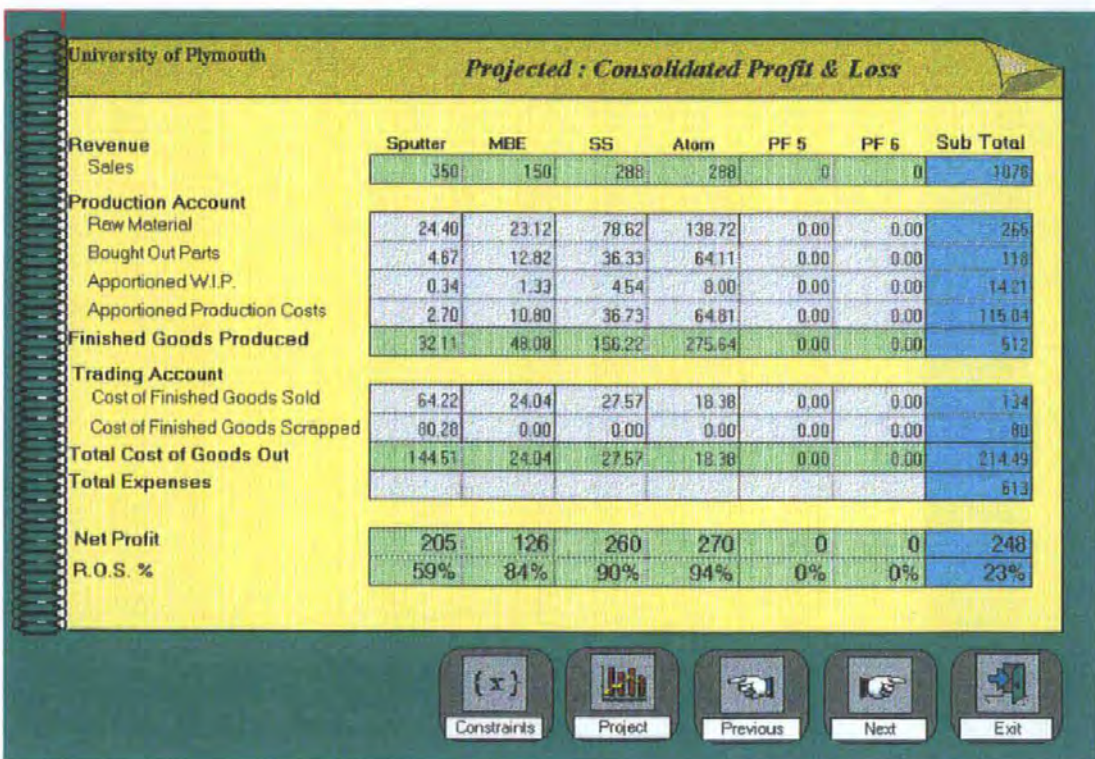


Fig. 8.4 - Results of Projection

Using the information gathered from the current financial model and the experimentation with financial projections, an appropriate business need may be identified. The appropriate

business need is selected from a list presented by the CBT (Fig 8.5). In addition to selecting the appropriate business need the CBT provides a list of areas within the business which could change to meet the identified business need (Fig 8.6). For example, the business need to reduce costs may be identified and changes to the product design may be recognised as an area which could potentially change.

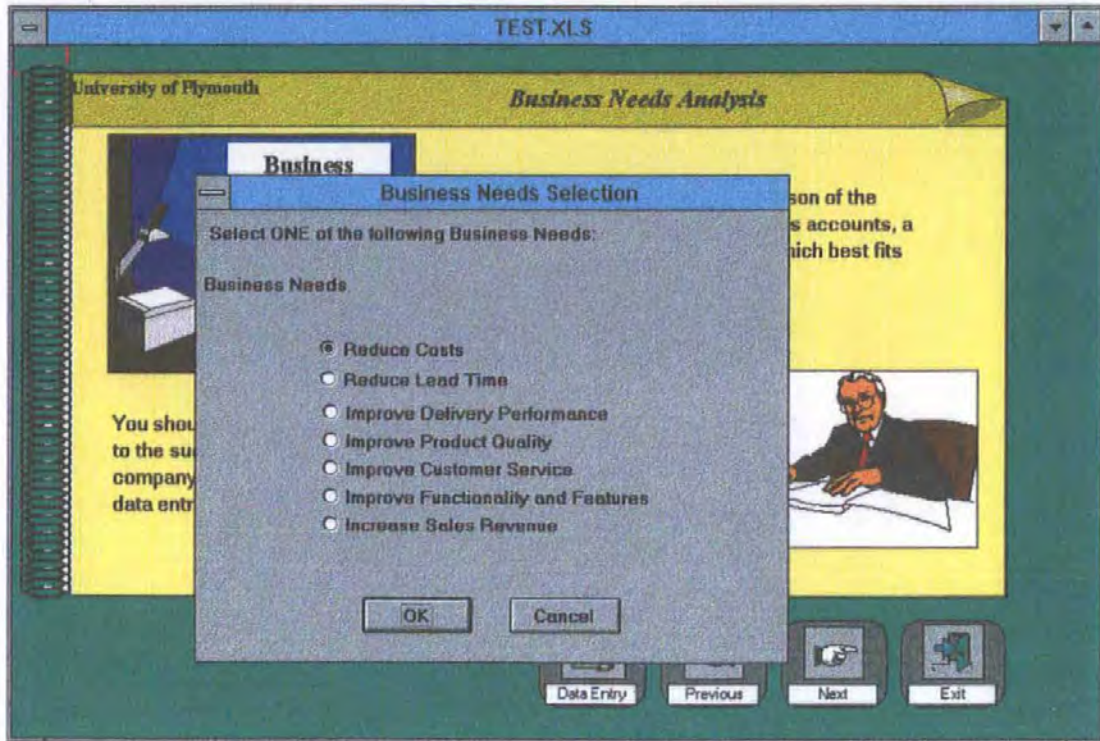


Fig. 8.5 - Business Need Selection

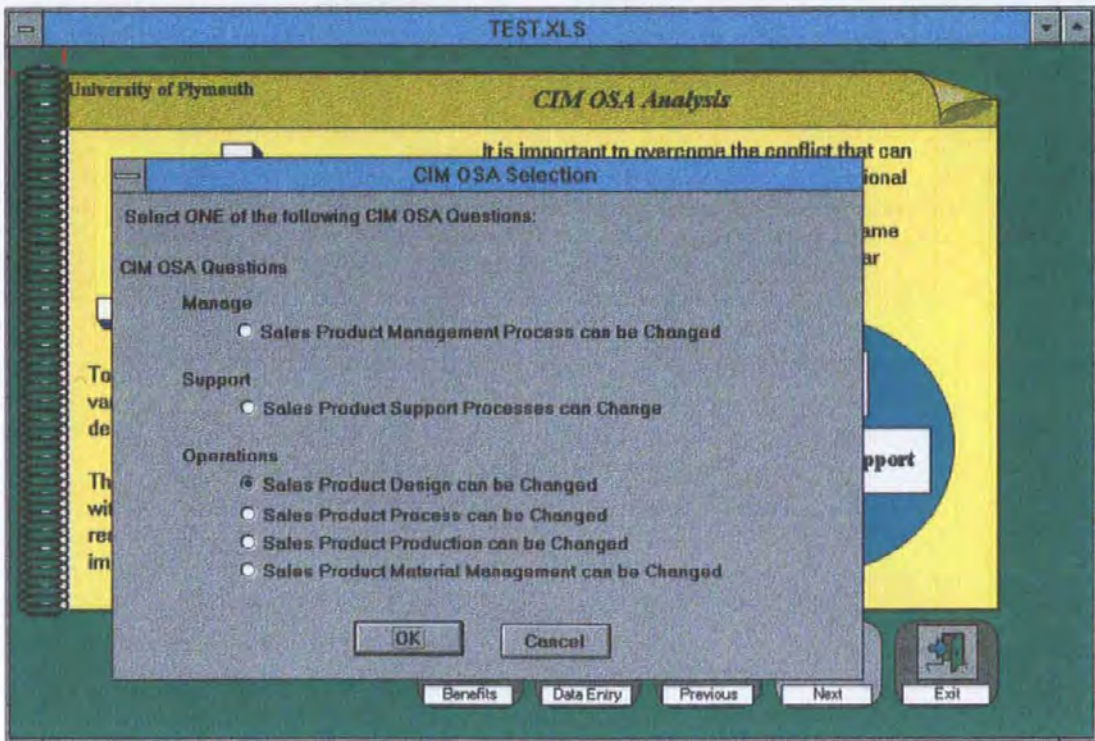


Fig. 8.6 - Selection of Target Area for Change

Once this information is entered into the CBT a list of potential technologies is automatically compiled for the user (Fig 8.7). Using a similar method to that used for the selection of business needs, an appropriate technology is selected from a list compiled by the CBT. For example, CAD may be selected to address a reduction in costs when the product design is identified as a candidate for change.

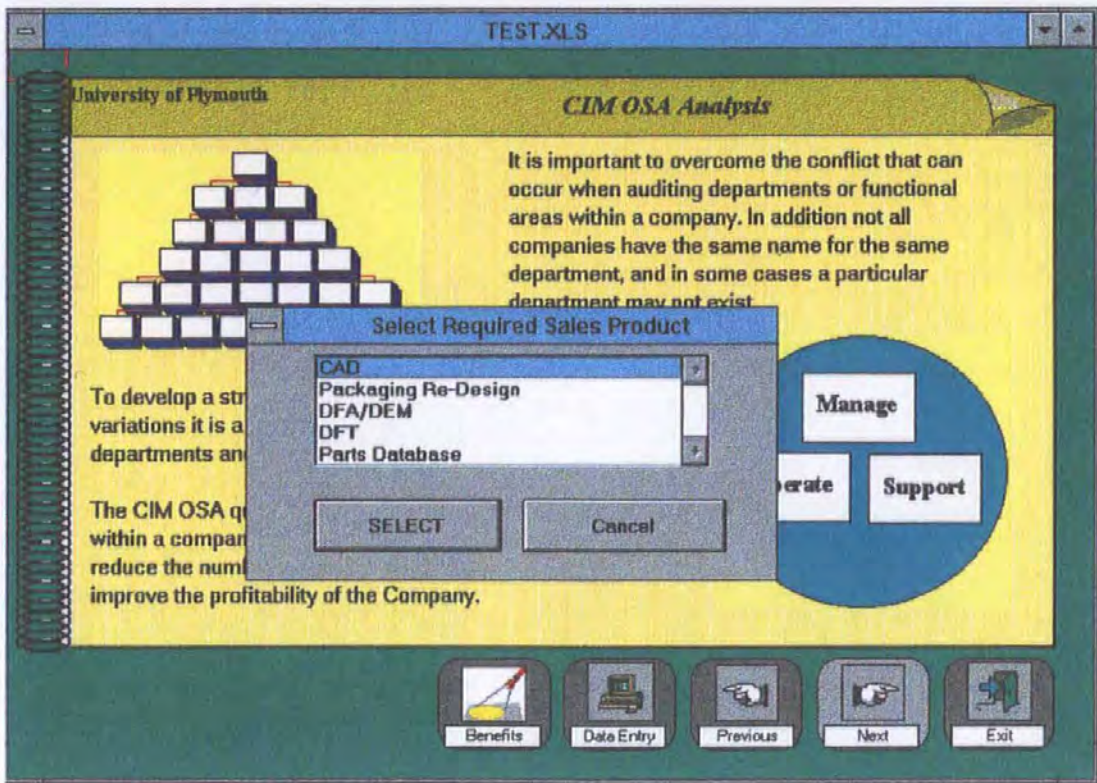


Fig. 8.7 - Selection of Technology

Based on the entire set of information provided by the user, the CBT compiles a list of potential benefits that are associated with the implementation of the selected technology (Fig. 8.8).

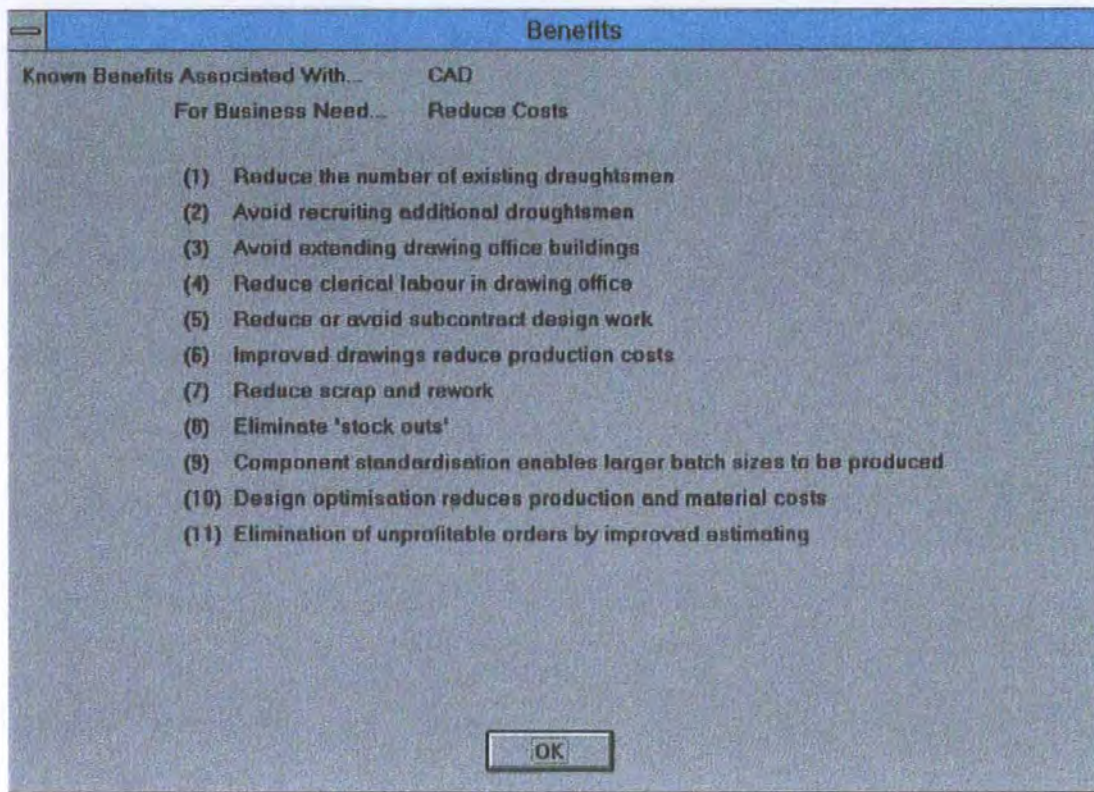


Fig 8.8 - Benefits of Technology Implementation

A major difference in the approach taken to provide tool and technique support for the methodology is that the complexity associated with each analysis is hidden from the user. This approach is described by Larsen and Hughes (1994). While this facilitates a reduction in the complexity presented, a potential problem is that the results of analyses presented to the SMEs may be questioned due to a lack of knowledge regarding the method by which the solutions are formulated. Analyses used within the methodology were highly automated. The learning which could take place from the operation of the tool is from the experimental manipulation of the data used in the analyses, and the observation of the results. In addition, learning facilitated by the transfer of knowledge regarding the benefits of technologies was also addressed.

8.2.5 Decision formulation and decision support

While the previous section indicated that the analyses conducted within the methodology were highly automated, it should be recognised that the results of the analyses are presented to the SME to support decision making. While the CBT may influence these decisions based on the results presented, the final decisions rest with the participants of the project and their agreement on appropriate action.

8.2.6 Project management

The project management features found to be successful in prototype one, were not incorporated into the PROFIT tool. It was agreed at the design stage that the scheduling and management of the process would be undertaken by the workbook.

8.2.7 Group working

As in the case of prototype one the approach taken to facilitate group working was the integration between CBT and off-line documentation. The off-line documentation was supplied via the workbook with the exception of the results of financial modelling and analyses. It was envisaged that the results generated by the CBT could be printed and distributed to participants for decision making. The utilisation and management of appropriate human resources was not considered during the design of the tool. This was the result of the control of the process residing with the methodology workbook, and the CBT operating in a supporting capacity.

8.2.8 Summary of features

The table shown below (Table 8.1) provides a summary of the features which were incorporated into prototype 2. The framework used is consistent with the identified set of features (Chapter 6) and the framework used to evaluate prototype 1 (Chapter 7).

Features of CBT - prototype 2
Role of CBT: The role of the PROFIT CBT was to provide support for the methodology workbook in the form of automated analyses, the facilitation of financial modelling, and the transfer of knowledge regarding the benefits of appropriate advanced manufacturing technologies.
Structure and guidance: The structure and guidance for the methodology was provided by the workbook. The workbook utilised a systematic structure. The CBT supported the workbook by the provision of 'previous' and 'next' operations through the modelling and analysis tools.
Tools and techniques: The tools and techniques provided by the CBT centred around financial modelling. Analyses and projections of the financial model were provided by the CBT with a relatively high degree of automation. Potential technologies to address specific business needs are also presented by the CBT. The lists of potential technologies are automatically compiled based on previous input from the progression through the methodological process.
Decision formulation and decision support: The automated analyses in the CBT were designed to reduce the complexity of financial modelling activities required in the methodology. The results of analyses could provide support for the decision making by project participants.
Project management: The CBT was not designed to address issues of project management. The methodology workbook provided the scheduling and human resource allocation management.
Group working: Group working was facilitated by off-line discussion using proformas and templates provided by the workbook, and the results of computer generated analyses.
Interface: The interface layout was designed by specifying an area for the presentation of information and an area for control icons. The design of the information area was based on a profit and loss ledger book. The use of icons to control the CBT was designed to address the needs of novice users. Interface consistency was specifically addressed by maintaining both the consistency of the positions of control icons and their functionality.

Data entry: Data collection was facilitated by a series of separate data entry screens. Separate screens were used to collect detailed information on each component of the profit and loss model. The data was interpreted by the CBT based on predetermined formula. The design of the data entry forms utilised a colour coding to indicate where values were required.

Table 8.1 - summary of features of prototype 2

8.3 Prototype tests

As stated in Chapter 2 an objective of this research is to ensure its relevance for practitioners. This philosophy was maintained throughout the development and testing of the prototype tools.

The objective of the tests conducted on prototype two was to evaluate the use of a CBT as a supporting technology for internally driven interventions in SMEs. In addition the tests provide further insight into the design features which should be incorporated into the development of CBTs to transfer best practice knowledge.

The tests carried out on the structure and operation of the methodology have been reported previously (Larsen 1994). As suggested by Larsen (1994) the use of a CBT to support the methodology greatly enhances its application and scope. Larsen states:

'Because much of the analysis relies heavily on performing calculations and performing 'what-if' scenarios, which may become repetitive and time consuming, the CBT enables the cost justification analysis of one or a coherent programme of investments to be undertaken with greater ease speed and accuracy.'

The results of the prototype tests reported are generalised using the framework of features presented in Chapter 6, and which has been previously used to evaluate prototype one (Chapter 7). The consistent use of this framework facilitates a more coherent assessment of

the approach which should be undertaken to develop computer based best practice delivery mechanisms and the features which should be incorporated to address the needs of SMEs. The generalisation of features includes the assessment of the methodology by two companies and the application of company specific data to the CBT. The results of the application of the methodology by two companies have been documented previously (Larsen 1994). A description of the companies involved, and a brief summary of the findings are described in the following sections. The results are described while maintaining their anonymity.

8.3.1 Company C

Company C is a manufacturing SME which produces fluid dispensers. The company employs 65 people. At the time of the PROFIT validation the Company had identified a need to increase its capacity in order to improve its profitability. Using the methodology and CBT the Company identified that the purchase of an additional machine would increase the capacity of manufacturing to a level which would yield a satisfactory increase in the profitability of the Company (Larsen 1994). Company C found the overall process to be useful in guiding and supporting the selection of appropriate investments.

8.3.2 Company D

The second company involved in the PROFIT validation, Company D, is a small manufacturing Company which employs only 27 people. The Company is involved in the production of scientific instruments. The Company strategy was to increase its profitability through a combination of cost reduction and improved customer service.

Company D found the methodology relatively easy to apply and through financial modelling and projection identified two potential technologies. These technologies included the re-negotiation of supplier contracts and the training of its delivery personnel. The investment in these two technologies was identified as affecting two sales product families. The company found the facilitation of 'what-if' scenarios through the projection of profit and loss components to be useful.

8.3.3 Evaluation results

The evaluation results regarding the role and design features of the PROFIT CBT are an accumulation of the feedback obtained from companies C and D and from academics and practitioners who periodically reviewed its development.

Role of CBT: The CBT was found to provide essential support to the methodology. The facilitation of on-line simulations and projections were identified as having a distinct advantage over manual financial modelling methods. The integration of the CBT with the workbook was identified as requiring further work. It was suggested that the workbook should clearly indicate the relevant analyses that should be undertaken at the appropriate point in the process.

Structure and guidance: The structure and guidance for the approach was found to be practical and intuitive by the test companies. The methodology structure together with appropriate guidance through the process was presented by the methodology workbook, and was found to be informative. A systematic progression through the supporting tools and techniques was facilitated by the CBT. No problems were encountered by the practitioners in progressing through the CBT.

Tools and techniques: The provision of financial modelling and projection facilities was found to be an essential part of the approach. The use of the tools and techniques to support the identification of specific company needs, and the selection of appropriate technologies were found to be relatively easy to use and informative. The tools and techniques were found to provide an appropriate environment for context specific learning. The presentation of potential technologies to address business needs and the benefits associated with their implementation were considered to partially address the need to transfer knowledge associated with best practice.

Decision formulation and decision support: The philosophy adopted by the approach was to provide evidence and support for decision making using the results of computer based analyses. A potential problem that was observed during the tests was that practitioners attempted to identify the methods and formulae that were used in the calculations of the financial model. Attempts to validate the logic were recognised as a potential distraction away from the creation of the model and could undermine the SMEs confidence in the modelling process.

Project management: The management of the PROFIT process was not handled by the CBT. Practitioners found the project management provided by the workbook to be useful.

Group working: As in the case of the project management features, the majority of the group working activity was managed by the methodology workbook. This included the distribution of pre-work, proformas and toolkits and the arrangement of workshops to gain consensus and make decisions. The integration of the results of analyses provided by the CBT and the consensus building workshops was identified by the practitioners to be an

essential feature of the approach. The provision of facilities to output the results of analyses to hard copy were not provided in prototype two. While this functionality was not provided, it was recognised that the testing of this feature in prototype one had given sufficient insight into the success of this design feature.

Interface: Few issues were raised regarding the interface design. The practitioners were able to operate the CBT using the iconic control buttons after a little familiarisation. An issue regarding the format of the financial information and the units which were represented was indicated as a potential area where enhancements of the interface could be made.

Data entry: Practitioners found the data entry facilities sufficiently simple to operate. Initial questions were raised regarding the inconsistency between the detail of data entered and the detail of information displayed. This was explained to the companies by describing the data requirements of the hidden formulae which produced the consolidated financial model. Additional difficulties were also initially found in the colour coding of the data entry fields. After a short explanation and a description of the colour coding key, no difficulty was found.

8.4 Conclusion

This chapter has built upon the research described in Chapter 7 to identify an appropriate role for a computer based tool for intervention in SMEs and for the delivery of best practice knowledge. The objective of prototype two was to assess the use of a CBT to support a methodological process delivered by a workbook based mechanism. The feedback obtained from practitioners has indicated that the CBT had an essential role in supporting the

activities associated with the financial modelling and projections required by the PROFIT methodology.

A number of design features incorporated into the CBT have been described, and their evaluation by practitioners has been presented. An important factor which has been identified from the tests is the extent to which the complexity of analyses should be hidden from the user. Attempts by practitioners to validate the logic used within the CBT analyses have indicated that explanations should be made available to the user describing the underlying logic. In order to maintain the simplicity of the operation of the CBT it is envisaged that detailed information should only be provided on request.

In the cases of both prototype one and two, the CBT has assisted SMEs to undertake change projects to improve areas of their businesses. The CBTs have both been regarded as appropriate intervention mechanisms for SMEs which facilitate the achievement of context specific analyses, project management and human resource management in the change projects. The CBTs have facilitated a degree of context specific learning.

The idea of incorporating learning into the CBT is explored further in the next chapter and is investigated using the third prototype (Chapter 10).

CHAPTER NINE - Computer based knowledge transfer

9.0 Introduction

The previous chapters have presented two prototypes which have indicated that CBTs are a feasible mechanism for intervention in SMEs. The prototypes have also provided a degree of context specific learning via the provision of a set of tools and techniques. This chapter focuses more closely on one of these dimensions, the delivery of best practice knowledge via the creation of appropriate learning experiences. The objective of this phase of the research was to identify characteristics of instructional design which promote effective learning. Utilising technology to create appropriate learning experiences requires an understanding of human learning, and the means by which such learning may be facilitated via instruction. The findings from this work are used to influence the design of a third prototype to evaluate an exploratory learning based approach. A description of both the development and the results of practitioner evaluation of prototype three is presented in Chapter 10.

Although little research has been conducted which addresses the design of these mechanisms specifically for the Production and Operations Management domain, much research has previously been conducted in the educational area. Drawing extensively from this work, a number of issues are highlighted which provide a basis for the development of CBTs to create a learning environment for the transfer of best practice knowledge to SMEs.

Following a discussion of the context of this research, the chapter briefly presents a set of features of good learning which have been identified from the literature. Utilising a model of instructional design as a framework, the chapter discusses a range of issues for

consideration prior to the design of the third prototype. The issues within the framework identified are relatively large in scope. The chapter focuses on the sequence and control of learning which may be provided, and the communication between delivery mechanism and learner. The discussion also considers the capabilities of modern technology to address the design issues.

9.1 Context

A focus on the learning dimension of best practice delivery is supported by the work concerning learning as a source of corporate improvement and competitive advantage. The title 'Learning Organisations' (Argyris 1982, Schein 1993, Senge 1990a, Senge 1990b, Garvin 1993) has been used to describe institutions which explicitly recognise the advantages of adopting a corporate learning approach. There is much academic interest in learning organisations, but many of the descriptions are utopian and lack clear definitions and guidelines to aid and support industry (Garvin 1993).

However, learning does not only occur in organisations which explicitly identify a learning process. Learning occurs whether a conscious decision to learn has been made or not (Kim 1993) and is both initiated and developed through the individuals which interact with, and form the organisation (Cohen, M. 1994). This implies that for an organisation to learn, it may be beneficial to stimulate the learning of individuals within the organisation.

9.1.1 Learning focus

Laszlo and Castro (1995) discuss the use of interactive learning technologies in challenging current educational values. Historically, the role of education has been to produce 'knowers'. In a situation where a finite set of probable challenges is identified, it is sufficient

to acquire a set of known methods and means to deal with the array of eventualities. In environments which are dynamic, the educational system should be oriented towards 'learners' instead of 'knowers'. In such situations learning responses are required to adapt to the changing needs of the environment. New technologies may help to provide these learning responses as they will foster inquisitiveness and exploratory behaviour.

These ideas may be applied to manufacturing. Chapter 3 indicated that best practice was dynamic, that organisations need to continually experiment in order to establish better ways of working, and that they need to adapt these better ways of working to enhance their competitiveness. Laszlo and Castro (1995) suggest that it is possible to recognise that past knowledge does not necessarily aid present situations however, and that learning in the present can include knowledge of the past, and can even influence the future.

In addition to the delivery of best practice considered in this research, a range of organisational behaviour and culture issues need to be addressed. Whilst the behavioural changes required to encourage corporate learning and the effect of best practice concepts on current organisational practices are recognised as major issues, they are considered to be outside of the scope of this work.

9.1.2 Deficiencies of technology based solutions

A major deficiency of many approaches for the development of computer supported learning mechanisms is highlighted by Hannafin and Phillips (1987). Historically, the capabilities of the emerging and evolving technologies are offered without any consideration of any model of learning. Consequently many instructional technologies have yielded disappointing results. Although the need does exist to utilise these technologies, there is

also a need to recognise the features of human learning. To address this important concern it is useful to draw on existing instructional research.

9.2 Models of Learning

Learning theories are embedded in the design of technology-based mechanisms for learning whether the designer has incorporated them intentionally or not (Plowman 1989). The need for a focus on and re-examination of models of human knowledge and learning to realise the potential of modern instructional technology is required (Jagodinski, Phillips *et al* 1995).

Research in the area of human learning has resulted in the creation of many different explanatory models for the encapsulation of human knowledge. This complexity also filters through to the field of instructional design where many models of instruction have been formulated. However, before these instructional models are considered it is useful to obtain an understanding of the generic features of good learning. The framework, presented by De Corte (1993), provides a useful insight into human learning and may be summarised as:

1. Constructive - this feature emphasises the importance for learning to be learner-centred. Meaning is created from cognitive processing.
2. Cumulative - learning is based on the linkage of prior and existing knowledge. However, the learner's existing misconceptions can cause learning difficulties and changing a learner's skills and ideas can be difficult.
3. Cooperative - the cooperative feature of learning indicates the benefits which may be gained from social interaction where learning common concepts and skills is achieved cooperatively (Sharan and Sharan 1992). This feature is beneficial when the learning is

conceptually complex (Cohen, E. 1994).

4. **Self-Regulated** - good learning requires powerful meta-cognitive characteristics such as planning, managing, reflecting on knowledge. The design, control and guidance of the learning process should be handled by the learner.
5. **Goal-Oriented** - although learning may occur incidentally, it is more meaningful if it is based on explicit awareness of and orientation towards a goal.
6. **Contextual** - learning is enabled by linking it to real life context.

Although it may be recognised that the identification of 'good learning' for all situations and recipients is difficult if not impossible to achieve, the features of learning presented provides a guide for the formulation of requirements for the development of the delivery mechanism for best practice. This development may be further enhanced by basing the design of the mechanism on a model of instructional design.

9.3 Instructional Design

Bagdonis and Salisbury (1994) highlight the important role that models play in instructional design. A model of instructional design is provided by Gagne *et al* (1981), who present a set of nine external instructional events which are derived from, and may be mapped to, nine stages of the human learning process. These 'events of instruction' have provided the basis for much research in the area, including the rapidly advancing area of multimedia (Sweeters 1994). Hooper and Hannafin (1988) simplify these nine 'events of instruction' to five main stages which include:

- **Orientation** - attention gaining and motivational issues.
- **Presentation** - communication from delivery mechanism to learner.
- **Sequence** - learner control, guidance and help.
- **Encoding** - storage and retention of information.
- **Retrieval** - recall of stored information.

These stages provide a useful framework for the consideration of instructional design research. Focus is particularly applied to the areas of presentation and sequence. From the experiences gained from prototypes 1 and 2, it is perceived that these stages of the model will be predominant in the design of the computer supported learning prototype (prototype three) to deliver best practice concepts.

9.3.1 Orientation

The orientation stage of this model is concerned with gaining the attention of the learner and providing the motivation to undertake the instruction. This stage is especially relevant when the relationship between the new knowledge provided and the existing knowledge of the learner is not evident.

Explicit explanation of forthcoming instruction and its objectives can provide the focus required by the learner. However, in addition to the advantages of learner motivation, a possible disadvantage is that an effect of 'tunnel vision' may be caused where only the knowledge associated with explicit objectives specified is encoded by the learner.

An alternative approach for this stage is the use of advanced organisers which implicitly gain learner involvement. This method enables learners to elicit meaning to forthcoming instruction (Hannafin and Hughes 1988) in a more individualised manner. In this case the orientation phase is achieved in a more personalised manner by facilitating orientation based on individual perceptions and requirements.

9.3.2 Presentation

The presentation stage of this model is concerned with the generation of appropriate stimuli (communication from the mechanism to learner), and the structure of the stimuli in the learning program.

9.3.2.1 The design of stimuli

The design considerations for this stage include the surface aspects of design such as legibility, colour use, screen layout, typography and access structure. Other considerations include the consistency of both the appearance of these aspects and of the procedural usage. This ensures that the mechanism itself does not distract from the subject matter that it encapsulates. A distraction may occur if a relatively large amount of cognitive processing is required to operate the mechanism.

9.3.2.2 Combination of media - the potential of technology

In addition to the surface aspects of design identified, the selection and combination of appropriate media types is of key concern for instructional design. The design of educational media is a complex task which is the result of the growing number of different media types (Laurillard 1993). This is complicated further given the possibility of

integrating these media in a single delivery mechanism. Technological advances have enabled a single device to present multiple media formats (Kozma 1991).

Recently, phrases such as 'Multimedia', and 'Hypermedia' have been used to describe the integration of multiple media in a single delivery mechanism (Tolhurst 1995). These technological advancements complicate the selection of appropriate media for a given learning goal.

The perspective taken by Clark (1983) is that the media used to deliver instruction is merely a vehicle and does not influence student achievement. However, as Jagodinski, Parmee *et al* (1995) suggest, the power of instructional technology such as Multimedia and Hypermedia provide the potential to encapsulate learning sequences which create learning only achievable otherwise by practical physical experience. These technologies facilitate a mix of simulation, animation, text, video, still pictures (illustrations) and sound, and may facilitate experiential learning.

Educational media such as film and television can make learning more concrete by bringing the real world to the learner (Spencer 1991). This notion of multiple media formats is especially relevant where the transfer of best practice is concerned, particularly where situational meaning is required to facilitate an adaptation of the knowledge gained to fit specific organisational requirements.

9.3.2.3 Structure of appropriate stimuli

The method of structuring presentational stimuli is important for the creation of a successful learning environment. A consistent structure for accessing and linking the content in an

instructional tool is required. While this issue is considered in the sequencing stage of the model (Hooper and Hannafin 1988), the structure of stimuli from the perspective of its presentation is also important.

Reigeluth and Stein (1983) discuss the need for learning structures to be defined which allow the presentation of simple concepts which may subsequently be elaborated (elaboration theory) by the user. The analogy which may be used to explain this approach is that of a zoom lens (Clark 1994). The learner should be able to zoom in on appropriate stimuli from the more simple generic concepts, and then zoom back out to contextualise the learning which has taken place. The provision of a hierarchical orientation in a learning program could provide the framework by which the elaborations discussed by Reigeluth and Stein may be accommodated. This idea of hierarchical structure is not new in the field of Production and Operations Management as it is a central concept of systems theory.

A hierarchical framework as a means for linking elements of information is presented by Bentley (1992). The framework illustrates how a number of items of information may be associated, and expands on the notion of hierarchy by suggesting an additional axis of probable and possible links (Fig. 9.1.). The result of associating items of information would be an information architecture.

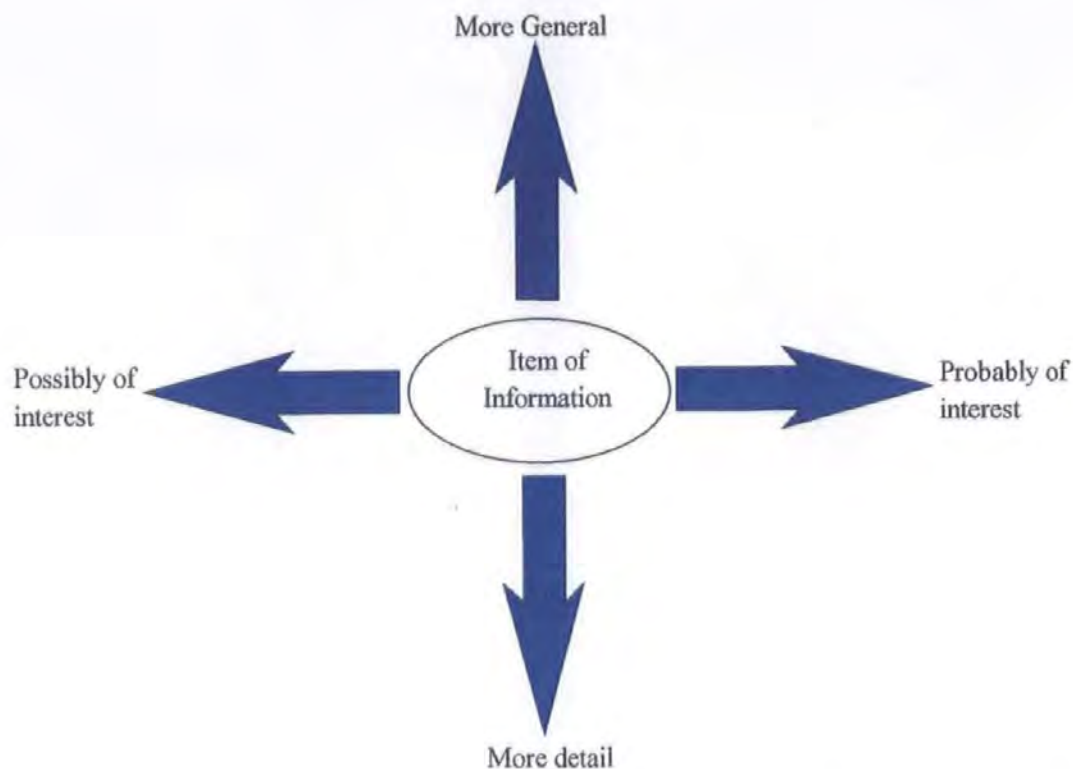


Fig 9.1 -Framework for linking items of information

The difficulty in implementing this framework lies in the identification of what units of information might 'possibly' or 'probably' be of interest to the specific need of a learner. However, using Bentley's model it might be possible to indicate 'associated' concepts at a particular level of detail within a hierarchy.

9.3.3 Sequence

A number of issues which should be addressed to enhance the learners ability to relate new information to existing knowledge is identified by Reigeluth and Stein (1983). These include:

- Increased learner control
- Access to help
- Provision of guidance
- Facilities to 'skip' and 'skim' material.

Increased learner control is concerned with the way in which both the user and mechanism respond and communicate with each other. This is known as interactive learning (Jonassen 1985) and is discussed further in the following section (Section 9.3.3.1).

From a review of the literature, Gay *et al* (1988) suggests that increasing the control the learner has of the environment provides increased productivity in learning. A consideration of the access structure which may be used to design information architectures which facilitate a high degree of learner control are described in Section 9.3.3.2.

9.3.3.1 Learner interaction

The term 'interactive' is loosely used in this domain to mean any form of learner communication with the computer based mechanism. Lucas (1992) expands the notion of learner-computer interaction and presents three models of interactivity which include reactive, proactive and interactive models of communication.

An example of the 'reactive' model is where simple key strokes advance the computer program to the next sequence. This model has been the most widely used in instructional technology and is derived from the behaviourist perspective of learning. This perspective is based on a stimulus-response orientation which is exemplified in many 'drill and practice' computer applications (Lucas 1992).

The situation where the learner may construct and deduce principles from their engagement with the mechanism is an instance of communication from the proactive stance. In this case the actual control or use of the mechanism constitutes a learning experience. This form of

learner interaction has been investigated in prototypes 1 and 2. The proactive model is becoming more popular and is derived from the cognitive perspective of learning. This perspective focuses on the learner constructing instruction themselves and is becoming more widely used in hypermedia applications.

The interactive model is a composite of both the reactive and proactive models. Examples of the interactive model are when the computer may provide coaching to the learner while the learner is attempting to perform a task. This model of interactivity may provide an approach for the transfer of best practice concepts (coaching), while the learner is undertaking a number of tasks which provide both experiential learning and the achievement of specific goals in the context of a methodological process.

9.3.3.2 Access structure

In addition to the mode of communication between learner and mechanism the issue of access to the structures which encapsulate the stimuli is of major concern. Many computer-based learning products are based on pre-programmed and sequential designs which impose a prescriptive structure upon the learner. The facilitation of learning which is directly relevant to a plethora of companies each with different requirements, perceptions, past experience etc. may not be provided by a prescriptive sequential approach. A structure which may be adapted and personalised for specific situations and learning goals is required, where the learner makes the explicit choice of what is to be learned. Recent advances in technology such as hypermedia make the provision of these architectural structures possible. This is exemplified in the network of nodes which may be traversed on the world wide web (internet).

Marchionini (1988) states that:

'Proponents of hypermedia systems model human associative memory and thus can serve as powerful cognitive amplifiers.'

Hypermedia facilitates the processes of association and exploration that are vital to learning and maintaining the motivation of the user. The functional perspective of hypermedia is that it has a node and link structure which enables the user to explore the content of the educational program in a non-sequential fashion (Knussen *et al* 1991). This functional definition is also reinforced by Welsh *et al* (1993) who utilise the hypertext definition of Conklin (1987) and suggest that it is a means of representing information in chunks or nodes and of providing a learner with the ability to navigate through the information by following relevant paths and links. If this technology is utilised to facilitate the delivery of best practice then the issues regarding the access structure and user interface of the program need careful attention.

9.3.4 Encoding

This stage of the Hooper and Hannafin model is concerned with the digestion or storage of information in human memory. Research has suggested that if presented information can be linked to the internal schema of the mind then encoding is generally more successful than if information is encoded in isolation (De Corte 1993). Hannafin and Phillips (1987) suggest that encoding is:

'an on-going process of instantaneous decisions to remember or not to remember'.

It is important to pace the series of instruction carefully so that time is made available for the encoding process to take place.

9.3.5 Retrieval

If the encoding phase has enabled a structural association between new and existing information, retrieval will be enhanced. The presentation of information is also important in this stage. Information which has been presented as being of more importance will be remembered as such. The techniques which could be employed in this instance are, for example, the underlining or highlighting of text. Personalising information also aids recall. This may be accomplished using company specific information in the proactive communication mode between computer and learner.

9.4 Issues for consideration

This chapter has presented the exploratory research conducted to identify design issues for the development of computer based mechanisms aimed at transferring best practice via the creation of appropriate learning experiences.

A framework highlighting some good features of learning has been presented. This framework indicates that learning should be learner-centred and should be based on the linking of prior and new knowledge. Good learning requires metacognitive characteristics, which may be partially facilitated by orientation towards a goal and if a meaningful context can be provided.

To further enhance the foundation for the design of best practice delivery mechanisms, instructional design models have been considered. A five stage model (Hooper and Hanafin 1988) which was derived from the 'events of instruction' model (Gagne *et al* 1981) has been used to structure the investigation of design issues.

The orientation stage of this model has enabled the identification of the usefulness of explicit instructional objectives, and the use of advanced organisers to facilitate learner awareness of the goals of instruction.

The presentation stage highlighted the need to consider the surface aspects of design and the consistent usage of procedure. The capabilities of modern technology to some degree complicate the selection of appropriate media for the delivery of best practice. However, capabilities such as the encapsulation of simulation, animation, video, still pictures, sound and text on a single delivery mechanism may facilitate learning experiences only achievable otherwise by practical experience. The structure of the presentation may utilise the concept of elaboration theory identified by Reigeluth and Stein (1983). In addition to this design concept it is recognised that the use of a hierarchical structure may provide a well understood architecture for the structure of the learning material.

The sequence stage highlighted the need to consider suitable access to help and the provision of guidance within the mechanism. The communication between the mechanism and the learner has also been considered in terms of three modes of communication. The use of the interactive mode may provide suitable mobility through the structure of the mechanism, and may be utilised to provide the delivery of best practice concepts. This mode provides guidance in addition to the learning experiences which may be gained from using tools and techniques embedded within the mechanism. The access structure may be facilitated by hypermedia technology which is based on a node and link structure.

The pace of the delivery of best practice needs to be addressed to ensure the encoding of the concepts by the learner.

Retrieval may be enhanced if an association between new and existing knowledge is achieved. Concepts which are presented as being more important will be remembered as such. Techniques need to be utilised to facilitate the presentation of key concepts.

The following chapter presents additional research conducted to investigate the incorporation of the instructional design issues identified into a computer based mechanism. However, having identified the scope of issues associated with instructional design, the research objective of the prototype was to focus on the presentation and sequence issues of a computer based learning environment for SMEs. The aim of the prototype described was to deliver concepts and principles associated with Business Process Re-engineering (BPR).

CHAPTER TEN - Prototype 3 - exploratory learning environment

10.0 Introduction

The previous prototypes described in Chapters 7 and 8 have indicated that CBTs are a feasible mechanism for intervention in SMEs and are useful for creating a degree of context specific learning. The learning which has been facilitated in these prototypes may be explained using the categorisation of learner interaction described by Lucas (1992) (Section 9.3.3.1). The learning experiences created within these prototypes fall within the proactive category in that the actual control of the mechanism constitutes a learning experience. Drawing from the issues associated with instructional design which were identified in Chapter 9, this chapter extends the research to address explicitly the development of a learning environment. The objective of this phase of the research is to evaluate the feasibility of computer based learning environments for the transfer of best practice in SMEs

Due to the constraints of time and the scope of issues associated with the development of learning environments, the development of the prototype focuses only on the design and implementation of a node and link architecture which may be used to encourage SMEs to explore a set of concepts and issues associated with Business Process Re-engineering (BPR). The development therefore focuses on the 'sequence' stage of the instructional design model presented by Hooper and Hannafin (1988).

Prior to a description of the prototype and the results of the evaluation of the approach, the chapter briefly introduces BPR and highlights a framework of fundamental issues suggested by Maull *et al* (1995).

10.1 Business Process Re-engineering

During the period of this research the author has been involved in an additional research project (Maull *et al* 1994) funded by the Engineering and Physical Sciences Research Council (EPSRC), to specify the requirements for a Business Process Re-engineering methodology for use within SMEs. The information presented in this section is drawn from the work undertaken on this project.

Over the past five years, Business Process Re-engineering (BPR) has emerged as a popular approach used by organisations seeking improvements in their business performance. This interest began with Hammer and his seminal article entitled 'Re-engineering work: Don't Automate, Obliterate' (Hammer 1990). BPR's rise to prominence as a powerful means of transforming business performance has led to the emergence of a number of 'gurus' in the field including Hammer (1990), Harrington (1992) and Davenport (1993).

Maull *et al* (1995) point out that although surveys have been conducted (Skinner and Pearson 1993, Harvey 1994) in the BPR area, little empirical research exists which identifies the key issues of BPR projects.

Through an extensive literature survey and visits to exemplar organisations, over twenty different approaches to BPR have been identified (Maull *et al* 1995). From these approaches a composite BPR methodology consisting of five stages has been formulated and was used as a research agenda for the BPR project. The composite methodology identified was:

- Phase 1 Identify or create corporate, manufacturing and IT strategies
- Phase 2 Identify key process(es) and performance measures
- Phase 3 Analyse existing process(es)
- Phase 4 Redesign and implement process(es)
- Phase 5 Monitor and continuously improve new process(es)

However, from an in-depth study of four companies, a study of exemplar organisations, and a survey of over 30 companies, Maull *et al* (1995) identify that there are six fundamental issues associated with the successful implementation of BPR. These issues are Scope of Change, Performance Measures, Human Factors, Information Technology, Strategy, and Process Architecture. These issues have been conceptualised as a high level framework which may be used to address more detailed concepts and principles of BPR (Fig. 10.1).

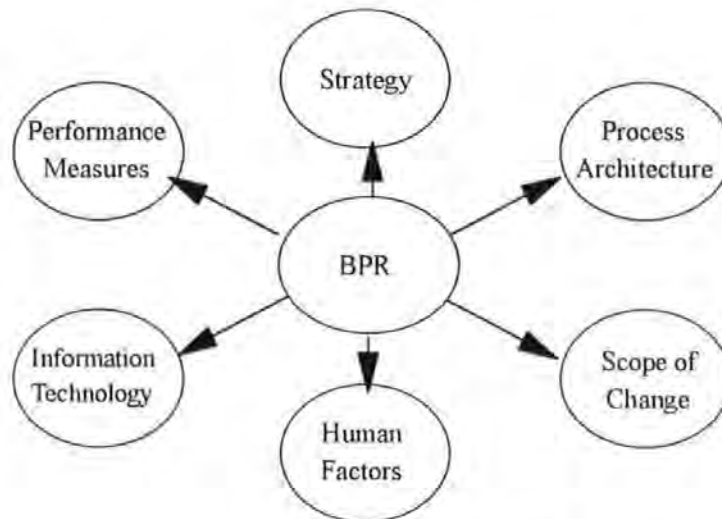


Fig. 10.1 - Fundamental issues for BPR

10.2 Approach for prototype development

The development of the prototype to create a learning environment for BPR needed a different approach to the previous prototypes. Prototypes 1 and 2 utilised the structure of their associated methodologies as a framework for accessing and progressing through the CBT to support an improvement process. The development of these prototypes may generally be regarded as a goal oriented approach for achieving increased performance within SMEs. Prototype 3 was not concerned with the methodological structure of a BPR project, but was concerned with providing an environment for the consideration of a set of fundamental issues identified as important for the success of a BPR project. The objective of prototype 3 was to create an exploratory learning environment which could be demonstrated to SMEs to encourage discussion regarding its usefulness.

The development of the prototype focused on the sequence stage of the instructional design model presented in Chapter 9 (Hooper and Hannafin 1988).

10.2.1 Information architecture development for Business Process Re-engineering

The main issue for this phase of the research was to address how a set of six fundamental issues for BPR could be structured into an architecture which could be accessed and explored by SMEs. Drawing from the earlier research findings (Chapter 9) it was envisaged that the prototype CBT should facilitate a high degree of learner control (Reigeluth and Stein 1983).

The initial design approach used to develop this architecture was based on the architectural orientation of hypermedia (Fig 10.2). This architecture is based on a node and link

structure, which would enable an SME to explore the content of the CBT in a non-sequential manner (Knussen *et al* 1991). It was envisaged that the approach should facilitate increased learner control, and should address the 'constructive' feature of good learning advocated by De Corte (1993).

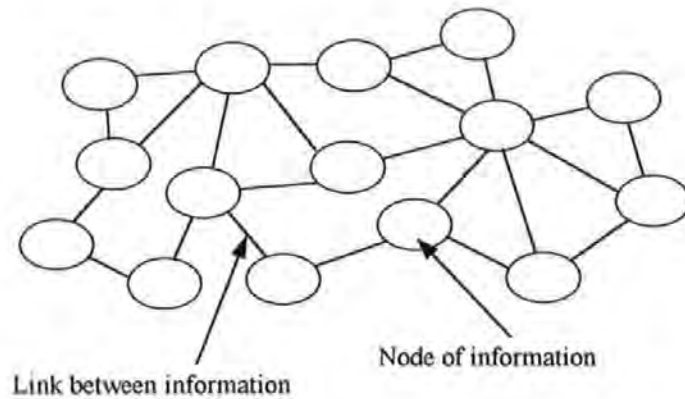


Fig. 10.2 Hypermedia node and link structure

Drawing extensively from the experiences gained during the BPR project, detailed elements of each fundamental issue was considered. A set of questions which SMEs may ask prior to or during a BPR project was constructed. These questions were not drawn from a survey of SMEs, but were based on the author's experiences from action research in process based change in small manufacturing companies (Appendix 2). Addressing these questions in the CBT, and describing tools and techniques which could be used for BPR, provided the content material for the nodes of the architecture. Questions which were formulated included for example:

Modelling

What is process modelling?

What role does process modelling play in a BPR project?

What are the appropriate techniques for process modelling?

Processes

What is a business process?

What are the advantages of a business process perspective?

What techniques can be used for business process improvement?

A potential problem which was identified during the initial design phase of the prototype was that if the architecture was implemented based on a two dimensional hypermedia orientation, SMEs may focus on an isolated area of the architecture which would not encourage the systemic consideration of all six issues.

The architecture was enhanced using the framework suggested by Bentley (1992) and the concept of elaboration theory described by Reigeluth and Stein (1983). Bentley's framework suggests ways in which information may be linked using a hierarchical structure. At each level of the hierarchy information which is possibly or probably of interest may be specified. The hierarchical orientation of Bentley's framework was used and the association of information at a particular level was based on an adaptation of the model (Section 9.3.2.3). The resulting architecture enabled a number of two dimensional hypermedia architectures to be integrated at different levels of abstraction (Fig 10.3).

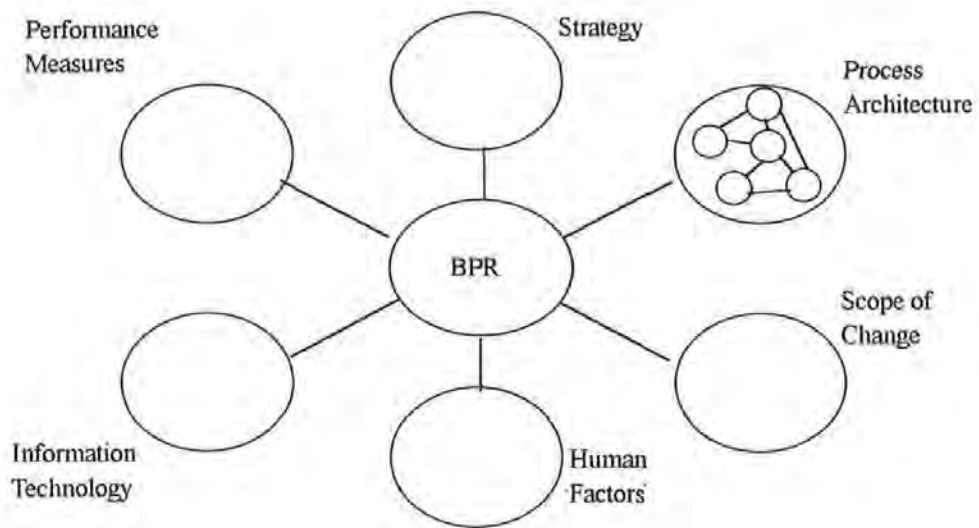


Fig 10.3 composite architecture

The architecture shown (Fig. 10.3) represents the context of the fundamental issues of BPR which is represented as a two dimensional node and link structure. An extra dimension is added to the model by specifying the detailed component parts of each fundamental issue. The example (Fig. 10.3) shows the additional structure within the Process Architecture issue. This detail represents a decomposition of the node. It was envisaged that the detailed areas of concern for BPR could be addressed at a level of decomposition, which may provide SMEs with the capability to focus on specific areas of interest and to contextualise the learning.

This architecture would also provide a structured top-down decomposition of issues which would facilitate the development of the CBT. This initial design would however isolate each issue in the framework from the other issues. It was recognised that a rigid decomposition within a fundamental issue did not represent the interrelationships which might exist between the issues in practice. From the research undertaken (Maull *et al* 1994) it is identified that these issues are highly related, decisions made in any one area is likely to affect the decisions in the others. It was envisaged that a more appropriate architecture

would include links between the information of a particular node and other nodes which had been decomposed (Fig. 10.4).

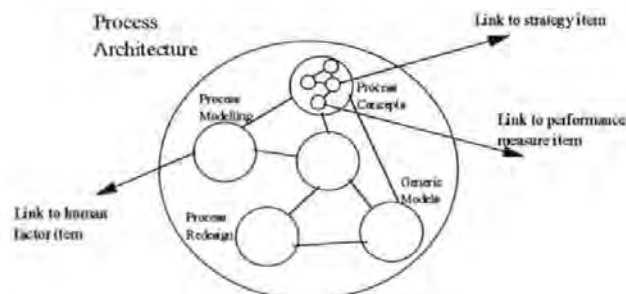


Fig. 10.4 - Internal and external links between nodes of information

While it is necessary to consider these interrelationships, the simplified model was used to implement the architecture. The implementation of the architecture in a CBT would provide a useful mechanism which could be demonstrated to SMEs to help them conceptualise the potential use and role of exploratory learning environments.

10.2.2 Computer based tool design

This section describes the design approach for the prototype CBT to implement the node and link architecture described. It was not the intention to create a complete implementation of a BPR learning environment, but to develop a CBT to help stimulate discussion with practitioners to identify the usefulness of the approach. This would be achieved through demonstrated explorations through the CBT, and discussions regarding its applicability.

10.2.2.1 Background research

The development of the approach began with identifying a suitable environment to implement the node and link architecture and to create dynamic illustrations combining

sound, animation and text. The authoring environment of Macromedia Director was selected as an appropriate environment as it facilitated the construction of dynamic sequences using a time based 'score'. After experimentation with the environment a number of sequences of illustrations were created to test the applicability of the environment for transferring concepts of BPR. The illustration shown (Fig. 10.5) is a screen capture of a dynamic animation to convey the advantages of a business process focus as opposed to a more traditional functional orientation.

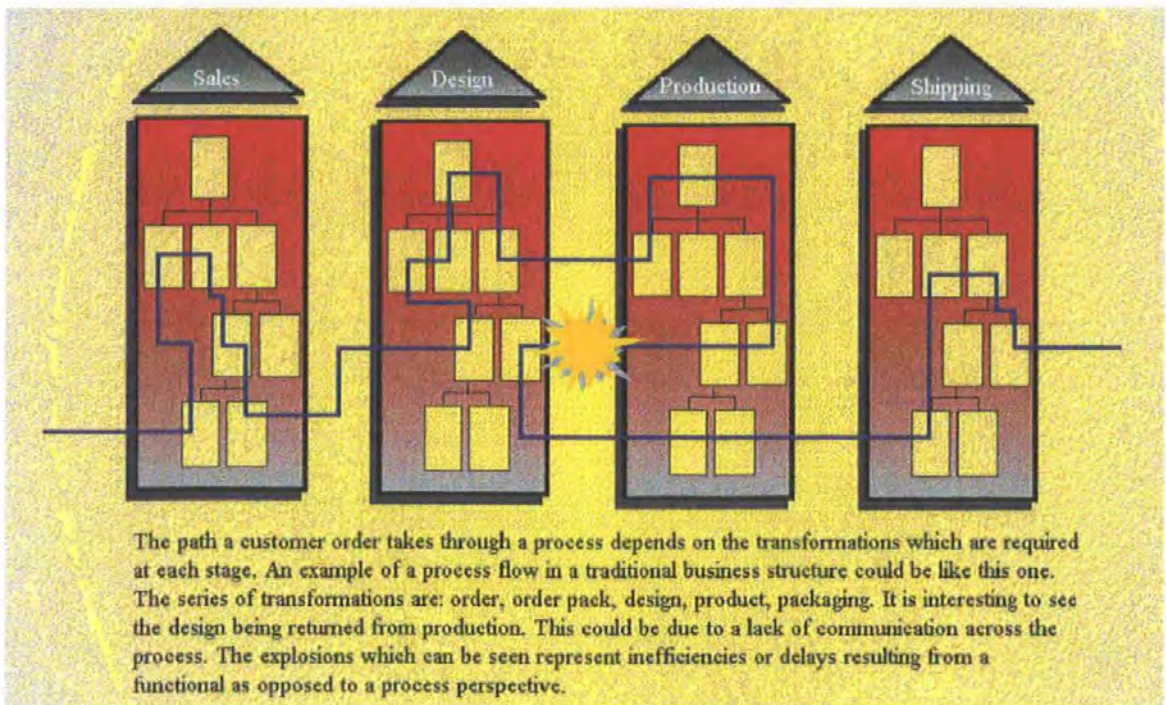


Fig. 10.5 - dynamic animation of a business process

Following initial experimentation it was realised that the time which would be required to implement the node and link architecture was beyond the intended time frame of the research. To overcome this problem the coding of the prototype was undertaken by the author's final year project student while the design of the prototype was undertaken by the author.

10.2.2.2 User Interface

The user interface of prototype three was based on a 'point and click' operation. An area at the bottom of the screen was designated as the control area, leaving the rest of the screen for the presentation of information. In addition to the control facilitated by the control area icons, additional control was provided by the navigation mechanism and the interaction with the dynamic illustrations. A diagram showing the layout of the interface highlights the design features incorporated (Fig. 10.6).

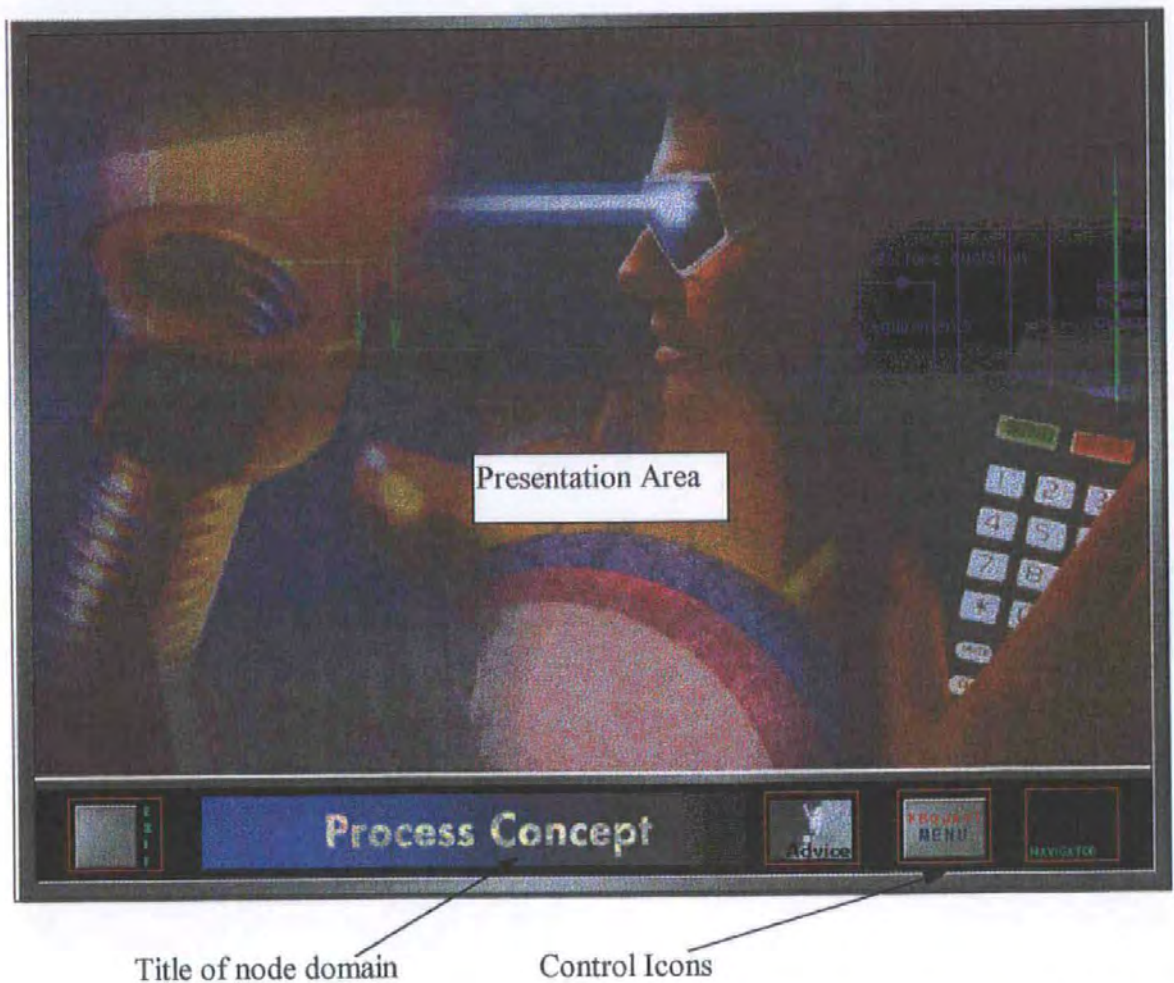


Fig. 10.6 - User interface layout

10.2.2.3 Implementation of node and link architecture

To provide a useful research vehicle in a relatively short timescale, particular attention was placed on developing the node and link structure and on developing the access mechanism for the specified architecture.

The mechanism for navigating through the CBT was designed utilising the structure of the architecture. The navigation within the prototype was based on the selection of a node from a model of the architecture displayed in a 'navigator window'. This involved using the mouse and pointer to 'click' the required node. The selection of a node provided access to the detailed units of information which it encapsulated. A representation of a detailed node structure in the navigator window is shown (Fig. 10.7) below.



Fig. 10.7 Access mechanism for navigation

It may be seen from Fig. 10.7 that in addition to the detailed structure of the architecture, which is shown in the main window, an overview indicating the previous level in the

hierarchy together with the point of access to the current structure is also shown. This feature was included to illustrate how detailed units of information may be contextualised in terms of their parent structure, and to assist users in identifying their position in the architecture.

The operation of the CBT using this mechanism could allow a high degree of learner control (Reigeluth and Stein 1983), and could encourage SMEs to attain a more complete understanding of the fundamental issues identified. For example, a learner may decide that they have adequately addressed issues associated with strategy previously, but may require information on process architectures. An exploration of issues associated with process architectures may initiate a re-appraisal of the strategic approach initially considered.

10.2.2.4 Previewing information

To assist the learner in selecting appropriate units of information, a 'preview' feature was encapsulated within the tool. This feature was based on the concept of 'advanced organisers' which enables learners to make decisions regarding the selection of appropriate instruction (Hannafin and Hughes 1988). An example of this feature is shown in the screen capture (Fig. 10.8). The preview windows are activated by the user rolling the mouse pointer over a node of the architecture in the navigator window. A preview window would therefore be presented to the learner prior to traversing the architecture.

The preview window of the prototype CBT does not in fact contain preview information but was implemented to facilitate discussion regarding this feature during demonstrations to practitioners. In the initial design of the approach it was intended that the preview features would include a list of the learning sequences which could be accessed together with their

associated media types. This would allow a learner to select learning sequences based on the content of the sequence and the preferred media format. This approach would increase further the control the learner has of the learning to be undertaken.



Fig. 10.8 Preview mechanism

10.2.2.5 Media usage

For the purposes of prototype tests, the architecture which had been implemented was populated with narrated explanations and dynamic images. For example Fig. 10.9 shows the stages of explanation of a standard process model (Weaver 1995). While some of the presentation sequences used multiple media to illustrate complex principles, the full potential of an environment which facilitates a convergence of multiple media that may be used to create new learning experiences (Kozma 1991) was not realised. However, the

principles encapsulated within the architecture provided sufficient content for the evaluation of the mechanism by SMEs.

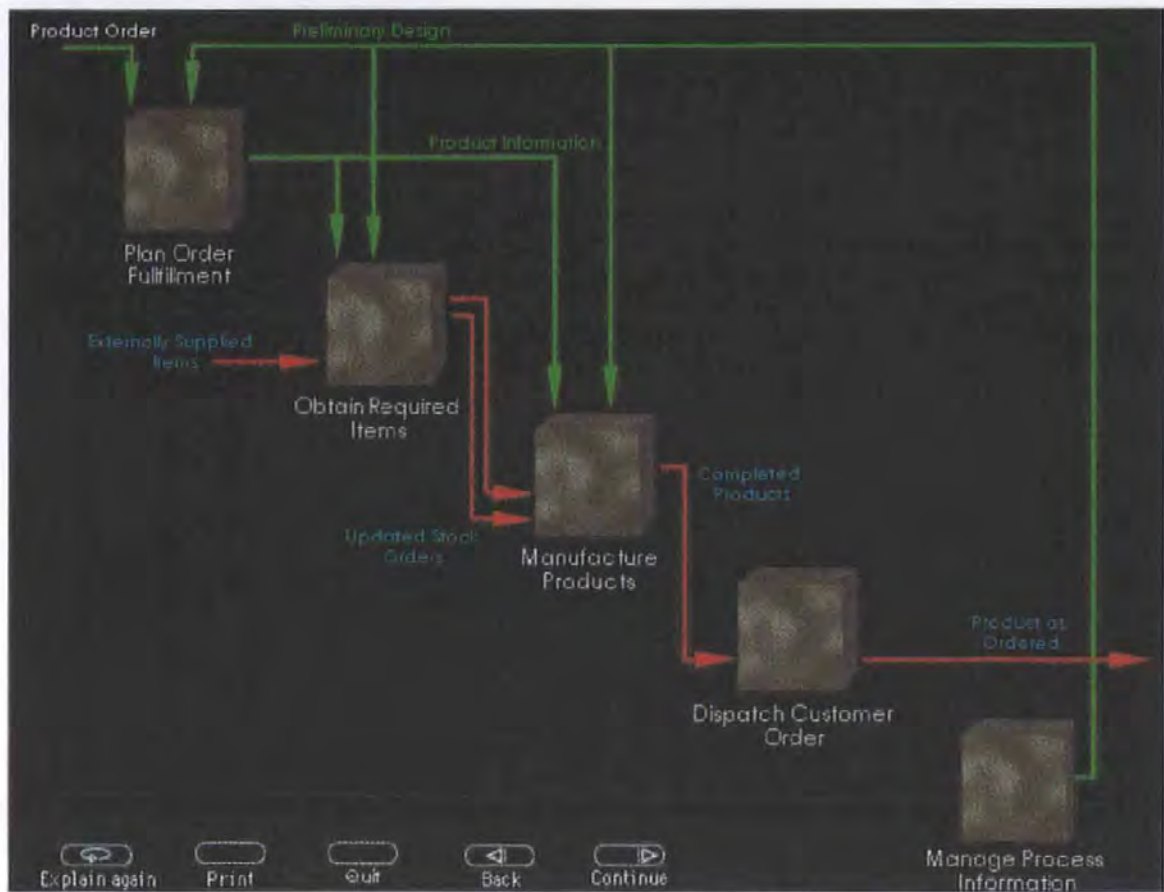


Fig. 10.9 - Instructional sequence of standard process models

It was also recognised that in some areas of the prototype a 'reactive' mode (Lucas 1992) of learner interaction had been created. The intended mode of learner interaction for the CBT was an interactive orientation. While this was recognised as a problem, it was identified that the parts of the prototype which had been designed as 'interactive' could be highlighted during a demonstration and explanation of the CBT. An example of an interactive component of the exploratory learning environment is shown (Fig. 10.10). This component facilitated the construction of a process model by the user, following an explanation of a standard process model.



Fig. 10.10 - Interactive component of standard process model sequence

The functionality included within the prototype provided practitioners with enough insight to comment upon its usefulness and recognise the potential of the approach.

10.3 Practitioner evaluation

The purpose of the practitioner evaluations was to establish the feasibility of using an exploratory learning environment to transfer best practice in SMEs. These evaluations were conducted in two stages.

10.3.1 Stage one evaluation

The first stage of the evaluation of the approach was undertaken at a seminar delivered by the author. The seminar was attended by 15 managers from local SMEs. The majority of these companies were undertaking or considering improvement initiatives.

A description of the framework of six fundamental issues of BPR together with a description of the architecture which had been developed to encapsulate the issues was presented. Ideas regarding the use of computer based tools as a mechanism for accessing

the architecture and for use to learn about the concepts and principles of BPR was described.

Following the presentation, company representatives were asked to consider the applicability of computer based learning environments for their company.

The responses gained further supported the earlier research and indicated that a need did exist for additional information and support if improvement projects or initiatives were to be undertaken internally by SMEs. One company suggested that a useful application of learning environments would be the ability to gain insight into the experiences of other companies which had undertaken similar projects. The majority of the other companies agreed, and it was suggested that there were benefits for the companies if a tool could be developed to support benchmarking.

The attendees of the seminar were asked if learning environments like the one described in the presentation would be used by SMEs. The general consensus of opinion indicated that the learning environment described would be a useful tool to help the companies think through the implications of best practice. However, it was noted that it would be difficult to justify the use of the CBT for learning purposes only. The reason for this was that there was no explicit goal or tangible benefit to the company which could be quantified. This supported earlier research which suggested that SMEs are unlikely to engage in any form of training or development unless it has an almost immediate payoff (Handy *et al* 1988).

At the end of the seminar, the Managing Director of one of the companies indicated that he would like to find out more about the approach. The second and more detailed stage of the evaluation describes these discussions.

10.3.2 Stage two evaluation

The second stage of evaluation involved detailed discussions with the Managing Director of Company E.

Company E is a small manufacturing company with 29 employees. The company is involved in the processing, testing and distribution of semiconductors. During the time of evaluation the company was embarking on a project to develop an integrated computer system, and was considering the implementation of Electronic Data Interchange (EDI).

The aim of this stage of the evaluation was to demonstrate the prototype CBT, to provoke discussion regarding the use of learning mechanisms in SMEs. Prior to the demonstration, the objectives of the research were indicated and the results of the earlier prototypes were described.

The prototype was demonstrated, and the MD was talked through how a complete CBT might facilitate learning in different areas of BPR. Difficulty was expressed in judging the prototype as it was an incomplete implementation of the architecture which had been described.

It was thought that the use of multiple media combined with a high degree of user interaction would be the most productive way to encourage employees to explore the

network. The MD agreed that the CBT could be useful to convey complex concepts of best practice. The hierarchy of the architecture was considered a practical way to structure the many complex issues associated with BPR. The navigator mechanism which had been developed to access and traverse the architecture was not considered to be of the required simplicity for SMEs to understand and use. A more simplistic 'front-end' would be needed to make the mechanism usable. This is an important research issue for the development of learning environments as the cognitive processing required to operate the tool would decrease the cognitive processing available to understand the information being conveyed.

Following the demonstration, the MD commented that the concept of a learning approach for SMEs was relevant. The importance of ensuring that the concepts of BPR were understood by SMEs was recognised, but in his view SMEs would not use the CBT in practice. It was suggested that SMEs are concerned with 'getting the product out of the door' and that, due to their busy schedule, a learning approach where benefits are difficult to quantify would not be seen as beneficial. After further discussion it was agreed that the CBT could be implemented to provide the required learning and support for a goal oriented approach based on a process consultation model. This approach could be used to improve upon the earlier prototype CBTs.

10.4 Conclusions

This chapter has presented an alternative approach for the delivery of best practice using computer based mechanisms. The approach has focused on creating a learning environment which SMEs could use to explore concepts, principles and issues associated with best practice. The research has been predominantly concerned with the development and

implementation of a node and link architecture which has been designed to encapsulate six fundamental issues of BPR.

A prototype CBT has been developed to implement the architecture specified. While the prototype was an incomplete implementation of the concepts and principles associated with BPR, the CBT has provided a useful research vehicle to help companies conceptualise the proposed approach, and to comment on its usefulness.

From discussions with SMEs regarding the feasibility of an exploratory learning mechanism, and the feedback obtained during a demonstration of the prototype, a number of general conclusions may be drawn.

An approach which explicitly focuses on the creation of a learning environment is useful to ensure that members of a project team understand the concepts and issues associated with the implementation of best practice. The use of multi-media in conjunction with a high level of interaction between user and machine potentially encourages exploratory behaviour and facilitates learning. A hierarchical structure of hypermedia architectures provides an overall architecture which is useful for dealing with the complexities and volume of concepts and principles of best practice. A hierarchical decomposition of nodes into sub-networks of nodes was identified as a practical way to structure complex sets of issues. It is also identified that this approach supports learning by providing the ability to contextualise the learning undertaken in terms of the fundamental issues of the best practice model. Further research is required to identify appropriate interface and access mechanisms for multi-layered hypermedia architectures.

The main conclusion from this part of the research is that the approach presented should provide additional benefits to the features of CBTs previously identified. These features specifically address the transfer of complex concepts and principles of best practice. Exploratory learning environments should however be implemented to support goal oriented approaches as presented in prototypes one and two. It is envisaged that a composite approach drawing on the research findings from the three prototypes presented would provide a more appropriate mechanism for the delivery of best practice to SMEs.

CHAPTER ELEVEN - Conclusions

11.0 Introduction

This work has proposed features of a computer based approach for intervention in small and medium sized manufacturing companies to deliver best practice and to support SMEs in the improvement of their work practices. From the initial descriptive research it is clear that the existing literature does not provide a definition of what best practice is or explain how it should be delivered to SMEs. Existing mechanisms are deficient in providing appropriate support for SMEs wishing to change and improve their manufacturing practices.

This research has presented a working definition of best practice, and has suggested that a computer based approach would provide a more appropriate way to deliver best practice to SMEs. Three prototype computer based tools have been developed, and have been tested by practitioners. The results of practitioner evaluations have provided an indication of the appropriate features for computer based tools for the delivery of best practice to SMEs.

Incorporating these features into a computer-based approach has been shown to overcome many of the deficiencies identified from the existing mechanisms available.

This chapter describes the conclusions of the research and indicates: the research method undertaken; the research problem which was identified; the results of the prototype evaluations; and the contribution and significance of the research. The chapter draws to a close indicating possible areas for future research.

11.1 The research methodology

The research method that was used was a composite of the research cycle and a prototyping cycle. The research cycle was a three phase cycle which included Description, Explanation and Testing. The Description phase included a detailed literature survey in the areas of best practice, modes of intervention, characteristics of SMEs, and models of instructional design. Elements of this descriptive research were extended through exploratory research in the form of a workshop with practitioners.

The Explanation phase was used to synthesise the findings of the descriptive research into a set of objectives for a computer-based approach and a set of features which may be incorporated to meet the objectives identified. Three prototype computer based tools were developed to provide a mechanism which could be tested by practitioners. Each prototype was designed using a subset of different features.

The Testing phase of the research involved the evaluation of the prototypes by practitioners. Observations from the use of the prototype computer based tools and discussions with the practitioners has enabled the feasibility of the approach and the features which should be incorporated to be identified.

The research methodology provided a useful structure to organise and manage the research and facilitated the production of new knowledge which should be used to help meet the requirements of practitioners. While the research cycle used was useful, the author now recognises that in practice it is difficult to consider rigid divides between the phases. For example, descriptive research and explanatory research may occur concurrently.

The prototyping cycle provided a useful approach to test the validity of computer based mechanisms. It would have been difficult for practitioners to conceptualise a computer-based approach and to identify its associated benefits without using a prototype.

11.2 Research problem

Changes in the competitive environment have strongly influenced many manufacturing companies to change their operations and work practices. Companies are seeking to adopt and develop best practice to improve their operating performance. Many 'thematic' models of best practice may be identified in the field of production and operations management. These models are usually imported into companies via the use of external consultancy services.

The use of consultancy services does not guarantee success, and the literature suggests that inadequate results have been obtained by SMEs engaging in client-consultant relationships. The inadequacy of these results may be explained by the installation of pre-defined solutions by consultants as opposed to adapting and implementing solutions based on specific company requirements. This may in part be explained by a lack of understanding of best practice.

This problem is particularly relevant for SMEs who have a limited amount of financial resources and expertise.

The aim of this research was to develop and validate an appropriate intervention mechanism to deliver best practice to SMEs. Specifically, an approach using computer based tools has been proposed. Research has been conducted to test the appropriateness of the approach,

and to identify the features of computer based tools which should be incorporated. A programme of work has been undertaken:

- to establish what best practice in manufacturing is;
- to identify the difficulties SMEs have in acquiring best practice;
- to identify the characteristics of existing best practice delivery mechanisms;
- to identify objectives and necessary features of computer based delivery mechanisms;
- to specify a suitable computer based approach for the delivery of best practice to SMEs.

11.3 Results of the literature survey

From a study of best practice, modes of intervention, and the characteristics of SMEs, it has been shown that current literature is inadequate in defining what best practice is and in suggesting appropriate mechanisms for the delivery of best practice to SMEs.

Chapter 3 indicated the need for practitioners to develop new ways of working to address the demands of the competitive environment. While much has been written about the need for companies to adopt and develop best practice, little has been written to define or explain what best practice means. Drawing from current literature a working definition of best practice was proposed. This definition provided a starting point which was used to extend the research and has provided a reference point for other researchers.

The research was extended through an analysis of best practice models which have been presented in the literature. A study of World Class Manufacturing and Lean Production models suggested that the benefits for practitioners are in the principles which are embedded within each model. A consideration of the implications of best practice

implementation indicated that a need exists to provide practical guidance for practitioners. The principles of a best practice model provide a useful theory-based frame of reference to change work practices. However, practitioners should not simply adhere to the principles but should identify the implications of changing work practices based on the theory. For example, it is commonly recognised that reductions in inventory provide benefits for companies, however, in practice inventory should not be eliminated mindlessly, rather the reasons for the existence of inventory should be first understood.

The research suggests that advanced manufacturing technology also provide benefits which may be utilised to improve manufacturing practice. The literature indicates however that technologies only provide the mechanism for improvements in manufacturing and it is from understanding the implications of the paradigm which lead to better manufacturing practice.

Current literature indicates that the take-up of best practice by companies is particularly poor. This may be explained in terms of a philosophy of imitation being applied by practitioners. The literature suggests that companies which are attempting to copy best practice may only be copying visible artefacts and not the rationale, implications and principles associated with the implementation of a particular model. Best practice should be adapted to meet the needs of specific environments, and should not be copied.

From this initial research it is evident that delivery mechanisms for best practice should:

- transfer knowledge regarding the principles and concepts of best practice;
- facilitate the adaptation of best practice to meet specific company requirements;
- provide practical guidance for best practice implementation.

From a study of the literature SMEs are characterised as having a lack of resources, a lack of expertise and skills, and a short range management perspective. The results of a workshop held with practitioners supported these characteristics.

Existing mechanisms which provide knowledge and expertise to support improvements of the work practices of SMEs are mainly consultants. The literature indicates that a difficulty in transferring knowledge in SME-consultant relationships is the lack of time and divided attention of practitioners. In addition, disappointing results have been identified from SME-consultant interventions. These results may be explained as the implementation of standard solutions without a full appreciation of practitioner requirements or the problem situation.

To provide the support required by SMEs there is a need to consider alternative mechanisms. While the literature describes different consultancy approaches and compares the relative merits of different intervention modes, little research is evident into alternative approaches to overcome the difficulties identified.

11.4 Objectives and features of computer-based approaches

The research has proposed a new approach for intervention in SMEs for the delivery of best practice. The approach uses computer based tools to overcome the deficiencies of existing mechanisms.

From the research a set of objectives for the proposed approach have been formulated.

These objectives were:

- to effectively transfer concepts and principles of best practice;
- to ensure the comparatively low cost of the mechanism;
- to efficiently manage participant time;
- to overcome the identified deficiencies and limitations of existing mechanisms;
- to facilitate management development.

To achieve these objectives the research has focused on identifying appropriate features of a number of aspects of the approach. The framework used to identify appropriate features was:

- The role that the CBT plays in the intervention process;
- The structure and guidance provided by the CBT;
- The use of tools and techniques;
- Decision formulation or support;
- Project management;
- Group working;
- User interface;
- Data entry.

From the evaluation of three prototype computer based tools (see Appendix 3), a synthesis of the successful features identified in each of these aspects of the approach is:

- The role that the CBT plays in the intervention process - the role that the CBT plays in the approach should be either an encapsulation of a process methodology and all of its associated components, or the support of a process methodology. It has also been

identified that exploratory learning environments should be used to support the CBTs encapsulating or supporting process methodologies.

- The structure and guidance provided by the CBT - a systematic step by step structure which can be controlled and managed with explicit tangible benefits should be incorporated into the approach. This supports the findings from the literature which suggest that change projects within SMEs need to be goal directed. Goals and objectives for each step in the structure should be specified. The use of a multi-layered hypermedia architecture should be used to provide the structure for a supporting learning environment. This environment can be used to explain complex best practice concepts utilising multi-media. The elaboration of concepts should be facilitated using an abstraction and decomposition orientation. This provides a capability for SMEs to consider the context of the learning undertaken at the detailed levels of decomposition within the architecture.
- The use of tools and techniques - tools and techniques should be used to progress through the steps of the methodology in the CBT, to provide appropriate results for off-line decision making, and to facilitate proactive learning. Encapsulating tools and techniques within the process facilitated an approach which is similar to a process consultation model. SMEs were responsible for analysing the problem and specifying corrective action with the guidance of the CBT. The tools and techniques facilitated the transfer of skills for diagnosis, and facilitated experimentation with specific company data. A degree of context specific learning from experimentation and from the use of the frameworks supplied by the CBT was achieved.

- **Decision formulation or support** - the computer based approach should provide support for the project team to make decisions. The CBT should not prescribe solutions, but should provide results of analyses which are performed on-line. The results of analyses are useful for stimulating discussion in consensus building workshops. This feature can be used to overcome the deficiencies associated with the prescription of solutions, and encourages SMEs to adapt the principles of the best practice model to meet their specific requirements.
- **Project management** - the project management features of the approach were recognised as essential to enable SMEs to manage the process. A process diary can be used to monitor the accomplishment of the steps in the process. The participants required to perform tasks within the process should be named, and supplied with objectives and deadlines together with supporting documentation. This approach is useful for SMEs who are characterised as having a busy schedule and divided attention which restricts the likely success of an intervention.
- **Group working** - the group working facilities which should be used within the approach are the provision of off-line workshops. Workshop activity should be scheduled by the CBT (or workbook if a supporting role is adopted) and documentation such as the results of analyses should be provided. The ability to print off the associated documentation to allow the participants of the project to work remotely and to discuss the results was found to be a useful feature. This approach facilitates the gaining of consensus of all participants involved.

- **Data entry** - the data entry features which were incorporated into the approach was the provision of on-line proformas which were a replication of the off-line documentation used to gather data. The approach should only request data which is relevant to a specific instance of the approach. For example, cost data was collected when cost reduction was selected as an option for improvement. This provided an efficient process which addresses the resource issues identified as a characteristic of many SMEs.
- **User interface** - a high degree of learner control for exploration through the architecture of the supporting exploratory learning environment should be provided. This feature supports the 'constructive' characteristic of good learning. An access mechanism which provides the learner (user) with information regarding their path through the architecture, and that indicates the level of decomposition which is being viewed is a feature of the user interface aspect of the approach. The facilities to preview forthcoming instruction prior to traversing the architecture was also considered a useful feature for this approach. This was based on the concept of advanced organisers which increase learner control regarding what should be learned. The mode of interaction for the approach should be 'interactive'. This creates a greater degree of user involvement and provides an environment which facilitates the transfer of complex concepts. Complex concepts may be transferred more effectively via the provision of dynamic illustrations and simulations accompanied by narration. This approach overcomes the difficulties identified in communicating complex concepts in client-consultant relationships.

11.5 Required approach for computer based tool interventions

The research undertaken has achieved the research aims and has indicated that computer based tools are an appropriate alternative mechanism for intervention in SMEs, and that they may be used to deliver best practice.

The research has enabled a set of features of CBTs to be identified which may be associated with a successful approach.

For CBTs to be a successful intervention mechanism in SMEs, the research suggests that:

- a highly structured, project managed approach is required;
- the design of a CBT should be based on a process methodology with identifiable goals and outcomes;
- tools and techniques should be carefully designed and encapsulated in the CBT to facilitate both the achievement of tasks within the methodology, and to enable experimentation and learning;
- the computer based mechanism should not prescribe solutions for SMEs. The results of analyses should be provided for consensus building and decision making;
- the research has indicated that a CBT may provide a supporting role to a workbook based process methodology, or may entirely encapsulate a process methodology;
- the use of exploratory environments to support a goal based approach provides further support for SMEs and for the transfer of complex best practice concepts.

11.6 Contribution of the research

While much research is going on in the production and operations management area regarding methods for improving and organising manufacturing, little research is evident to

provide alternative mechanisms by which new knowledge may be transferred. While many researchers acknowledge the need for research which is relevant for practitioners, little attention has been given to the means by which new knowledge may be structured and delivered.

The research presented in this thesis has drawn from the experiences of three prototypes and has proposed a new approach by which new knowledge in the POM area may be structured and delivered to practitioners. This has been achieved utilising a bridging research strategy, which has resulted in the identification of a new research track within the field. This has significant implications for the field, in that research with a high degree of practitioner relevance may now be made more accessible for many companies wishing to improve their operations and work practices.

Specifically, the contribution this research has made to knowledge within the field of production and operations management is by providing:

- a definition of best practice;
- an explanation of the deficiencies of existing mechanisms for the transfer of best practice to SMEs;
- a new computer-based approach which alleviates some of the problems of existing mechanisms;
- a specification of appropriate features for a computer-based approach in the context of SME requirements.

11.7 Future research

Further research is required to extend the validation of the approach presented and to consider further roles for computer based tools for intervention in SMEs.

The research has indicated that it is useful to integrate goal-oriented approaches and exploratory learning environments. A composite approach should provide SMEs with a highly structured intervention process which may be effectively managed, and an environment which facilitates the transfer of complex best practice concepts and principles which may be internalised and applied. Details on how this might best be done requires further research.

An additional area which requires research is the development of computer based environments for the transfer of experiences from exemplar companies. This requirement was identified in the seminar of the stage one testing of prototype 3. This would enable SMEs to learn from the experiences of others as opposed to learning from the application of proven theories and techniques. An interpretation of the experiences of exemplars may provide the stimulus for the creation of unique procedures and practices which provide increased competitive advantage.

The author intends to extend the research in this area and has been involved in the creation of a case for support which has been submitted to the Engineering and Physical Sciences Research Council (EPSRC). The proposal has been successful in progressing through the initial review stages and has been accepted by three independent reviewers.

References

A

Argyris C, 1982, *Reasoning, Learning and Action - Individual and Organisational*, Jossey-Bass.

Avison D E, Fitzgerald G, 1988, *Information Systems Development*, Blackwell Scientific Publications, Oxford

B

Bagdonis A S, Salisbury D F, 1994, Development and validation of models of instructional design, *Educational Technology*, April, pp. 26-37.

Balcon R, 1990, Educational Technologies for Small and Medium Enterprises, *DLT News*, Issue 2, March.

Bechhoffer F, 1974, Current approaches to empirical research: some central ideas, in Rex T, (Ed), *Approaches to Sociology*, Routledge, London

Bentley T, 1992, *Training to meet the technology challenge*, McGraw-Hill.

Beta Technology, 1994, Identifying and Satisfying the Skills Required of Small and Medium Sized Enterprises (SMEs), Report for the Engineering Council

Blake R R, Mouton J S, 1990, *Consultation - a handbook for individual and organizational development*, Addison-Wesley.

Brody, C M, 1991, *Co-operative learning and teacher beliefs: a constructionist view*. Presented at the annual meeting of the American Educational Association, Chicago, April

Brooksbank R, Kirby D, Wright G, 1992, Marketing and Company Performance: An examination of Medium Sized Manufacturing Firms in Britain, *Small Business Economics*, Vol 4, pp 231-236

Buffa E, 1982, Research in operations management, *Journal of Operations Management*, Vol. 1, No. 1, pp. 1-7

C

Camp R., 1989, *Benchmarking - The search for industry best practices that lead to superior performance*, American Society for Quality Control

Card S, Moran T, Newell A, 1983, *The Psychology of Human-Computer Interaction*, Lawrence Erlbaum Associates

Cash W B, Minter R L, 1979, Consulting Approaches: two basic styles, *Training and Development Journal*, Vol 33, No. 9

Checkland P, 1981, *Systems Thinking, Systems Practice*, J Wiley & Sons

- Churchman C W, 1971, *The design of inquiring systems*, Basic Books, NY
- Clark R, 1983, Reconsidering research on learning from media, *Review of Educational Research*, 53, pp. 445-459
- Clark B W, 1994, Constructing an integrated model of professional education, *Educational Technology*, July-Aug., pp.38-43
- Cohen M D, 1994, Individual learning and organisational routine: emerging connections, *Organization Science*, vol.2 No.1, Feb., pp. 135-145.
- Cohen E, 1994, *Designing groupwork. Strategies for the heterogeneous classroom*, New York: The Teachers College Press.
- Conklin J, 1987, Hypertext: An introduction and survey, *IEEE Computer*, 20(9), pp. 17-41

D

- Dale I, Kerr J, 1995, Small and Medium Sized Enterprises: Their numbers and Importance to Employment, *Labour Market Trends*, December 1995, pp. 461-465
- Davenport T H, 1993, *Process Innovation: Re-engineering Work Through Information Technology*, Harvard Business School Press, Cambridge, MA
- De Corte E, 1993, Learning theory and instructional science, *ESF-programme "Learning in humans and machines"*, St. Gallen, Switzerland, 5-6 March.
- Drinkall B, 1989, Technology Based Training, *Training and Development*, December
- DTI, 1993, *Manufacturing into the late 1990s*, HMSO, London
- DTI, 1990, *Manufacturing in the 1990s: the competitive response*, HMSO, London
- DTI, 1995, *Computer Supported Cooperative Work: a decision maker's briefing*, DTI/PUB 1678/3K/10/95/NP, June

E

- Emory C W, 1985, *Business Research Methods (3rd Edn)*, Irwin, Homewood, IL
- Er M C, 1987, Prototyping, participative and phenomenological approaches to information systems development, *Journal of Systems Management*, August, pp. 12-16

F

Fitzgerald L, 1991, *Consultancy and Service Provision: Intellectual, Comparative and Contextual Dimensions*, Warwick Business School Research Papers No. 34

Fuller P B, 1994, *Assessing Marketing in Small and Medium Enterprises*, *European Journal of Marketing*, vol 28, No 12, pp. 34-48

G

Gagne R M, Wager W, Rojas A, 1981, *Planning and authoring computer-assisted instruction lessons*, *Educational Technology*, Sept., pp. 17 -21.

Garvin D A, 1993, *Building a learning organisation*, *Harvard Business Review*, July-Aug., pp.78-91.

Gay G, Trumbull D, Mazur J, 1988, *Designing and testing navigational strategies and guidance tools for a hypermedia program*. *Journal of Educational Computing Research*.

H

Hamel G, Prahalad C K, 1993, *Strategy as stretch and leverage*, *Harvard Business Review*, March-April, pp.75-84

Hammer M, 1990, *Re-engineering work: don't automate, obliterate*, *Harvard Business Review*, July-August, pp. 104-12

Hannafin M J, Hughes C W, 1988, *Utilizing orienting strategies in the design of computer-based interactive video*, *Instructional Science*, 15, pp. 239-255.

Hannafin M J, Phillips T L, 1987, *Perspectives in the design of interactive video*, *Journal of Research and Development in Education*, Vol 21, No. 1, Fall, pp. 44 - 60

Handy C, Gordon C, Gow I, 1988, *Making Managers*, Pitman Publishing, London

Harrington H J, 1992, *Business Process Improvement*, McGraw-Hill, New York, NY

Harrison A, Storey J, 1996, *New wave manufacturing strategies: operational, organizational and human dimensions*, *International Journal of Operations and Production Management*, Vol. 16, No. 2, pp. 63-78

Harvey D, 1994, *Re-engineering: The Critical Success Factors*, Business Intelligence Ltd, UK

Harvey-Jones J, 1989, *Making it happen: reflection on leadership*, Fontana, London

Hayes R H, Jaikumar R, 1988, *Manufacturing's Crisis: New Technologies, Obsolete Organisations*, *Harvard Business Review*, September-October, pp. 77-85

Hooper S, Hannafin M J, 1988, *Learning the ropes of instructional design: guidelines for emerging interactive technologies*, *Educational Technology*, July, pp. 14-18.

Houldsworth E, 1992, Technology Based Training as a Potential Aid to Competitive Advantage: A Survey of Small and Medium Enterprises and Training and Enterprise Councils, Working Paper, Henley Management College

Hughes D, Tranfield D, Smith S, 1987, The development of a user led implementation methodology for integrated manufacturing systems within the electronics sector, SERC/ACME grant GR/E56577

Hughes D R, 1989, STRATAGEM - The Strategic Manufacturing Methodology, Workbook, Entrepreneurial Technologies Ltd

Hughes D R, Smart P A, 1994, Manufacturing Competitiveness- the role of best practice, in Platts K W, Gregory M J, Neely A D, (Eds), Operations Strategy and Performance - papers of the 1st International Conference of the European Operations Management Association, 27-29 June 1994.

I

Ibrahim A, Goodwin J, 1986, Percieved Causes of Success in Small Business, *American Journal of Small Business*, Fall, pp. 41-50

IEE, 1991, Colloquium on CSCW: some fundamental issues, Computing and Control Division, March

J

Jagodinski P, Phillips M, Rogers T, Smith C, 1995, Models of knowledge, learning and representation for multimedia learning environments, *Association for Educational and Training Technology Conference*.

Jagodinski P, Parmee I, Smith C, 1995, The elicitation, analysis and representation of knowledge of a multimedia learning environment for civil engineers, submitted to: *International Journal of Human Computer Science*.

Jayaratra N, 1994, *Understanding and Evaluating Methodologies - NIMSAD - a systemic framework*, McGraw-Hill, London

Jonassen D H, 1985, Interactive lesson designs: A taxonomy, *Educational Technology*, 25(6), pp. 7-17

Juran J, 1989, address to the winners of the MBNQA, in, Whittle, S. R., Smith, S., Tranfield, D., & Foster, M., 1992, 'Benchmarking: the downside of best practice', *Proceedings of the 7th International Conference of the Operations Management Association*, UMIST.

K

- Karlsson C, Alstrom P, 1996, Assessing changes towards lean production, *International Journal of Operations and Production Management*, Vol. 16, No. 2, pp. 24-41
- Katayama H, Bennett D, 1996, Lean production in a changing competitive world: a Japanese perspective, *International Journal of Operations and Production Management*, Vol. 16, No. 2, pp. 8-23
- Kennerley M P, Davies A J, Kochhar A, 1996, Manufacturing strategy, performance and best practices - the contribution of manufacturing planning and control systems, *Proceedings of the 3rd International Conference of the European Operations Management Association*, London 2-4 June, pp. 363-368
- Kim D H, 1993, The link between individual and organisational learning, *Sloan Management Review*, Fall, pp. 37-50.
- Knussen C, Tanner R G, Kibby M R, 1991, An approach to the evaluation of hypermedia, *Computers and Education*, 17, 1, pp. 13 - 24.
- Kolb D, Rubin I, MaIntyre J, 1984, *Organizational Psychology: a experiential approach to organizational behaviour* (4th Edn), Prentice-Hall
- Kozma R B, 1991 Learning with media, *Review of Educational Research*, Summer, Vol.61, No.2, pp. 179-211.
- Krafcik J F, McDuffie J P, 1989, *Explaining high performance manufacturing: the International automotive assembly plant study*, International Motor Vehicle Programme, MIT Press, Cambridge, MA

L

- Larsen P C V, 1994, *The development of a methodology for the cost justification of new manufacturing investments*, PhD Thesis, University of Plymouth, UK
- Larsen P C V, Hughes D R, 1994, CBT - On screen simplicity hides off screen complexity, The XXIX Annual International Conference of the Association for Education and Training Technology, Edinburgh, Scotland, April
- Laszlo A, Castro C, 1995, Technology and values: interactive learning environments for future generations, *Educational Technology*, March/April, pp.7-13
- Laurillard D, 1993, Balancing the media, *Journal of Educational Television*, Vol. 19, No.2, pp. 81-93.
- Lee G L, Oakes I K, 1996, Templates for change with supply chain rationalization, *International Journal of Operations and Production Management*, Vol. 16, No. 2, pp. 197-209
- Lees J, Lees D, 1987, Realities of Small Business Information System Implementation, *Journal of Systems Management*, vol 25, No 1, January, pp. 6-13

London Institute of Management Consultants, 1974, *Guide to Membership*, in Kubr, M (Ed), 1976, *Management Consulting - a guide to the profession*, International Labour Office, Geneva.

Lopez D A, Haughton D A, 1993, World class in Northwest electronics companies: distressing results for technology and MPC applications, *Production and Inventory Management*, Vol. 34, No. 4, pp. 56-60

Lucas L, 1992, Interactivity: what is it and how do you use it?, *Journal of Educational Multimedia and Hypermedia*, 1, pp. 7 - 10.

M

Marchionini G, 1988, Hypermedia and learning: freedom and chaos, *Educational Technology*, Nov., pp. 8-12.

Markham C, 1992, *The Top Consultant: developing your skills for greater effectiveness*, Kogan Page

Maul R S, Hughes D R, 1990, Stratagem - a systems methodology for matching manufacturing strategy to business requirements, *Proceedings of the 5th International Conference of the Operations Management Association*, University of Warwick 26-27 June.

Maul R S, Childe S J, Bennett J P, 1994, The specification of a Business Process Re-engineering Methodology for Small and Medium Sized Manufacturing Enterprises, Engineering and Physical Sciences Research Council (EPSRC) grant, GR/J95010

Maul R S, Weaver A M, Childe S J, Smart P A, Bennett J, 1995, Current Issues in Business Process Re-engineering, *International Journal of Operations and Production Management*, Vol 15, No. 11, pp. 37-52

Meredith J, 1981, The implementation of computer based systems, *Journal of Operations Management*, October, pp. 11-21

Meredith J, 1985, Results of the Manufacturing Management Council Study of Justification Procedures, Society of Manufacturing Engineers, Dearborn, MI

Meredith J, 1987, The Strategic Advantages of New Manufacturing Technologies for Small Firms, *Strategic Management Journal*, Vol. 8, pp. 249-258

Meredith J, Raturi A, Amoako-Gyampah K, Kaplan B, 1989, Alternative research paradigms in operations, *Journal of Operations Management*, Vol. 4, No. 8, pp. 297-326

Meredith J, 1992, Theory building through conceptual models, *International Journal of Operations and Production Management*, Vol 13, No 5, pp. 3-11

Miller D, 1989, President's statement and annual report, Management Consultancies Association

Mills J, 1995, *Manufacturing Strategy Formulation - Workbook*, University of Cambridge, March

Mitroff I I, Betz F, Pondy L R, Sagasti F, 1974, On managing science in the systems age: two schemas for the study of science as a whole systems phenomenon, *Interfaces*, Vol. 4, No. 3, pp. 46-58

Mount J, Zinger T, Forsyth G R, 1993, Organising for development in small business, *Long Range Planning*, Vol. 26 No. 3 pp. 111-120.

N

Neely A, 1993, Production/Operations management: research process and content during the 1980s, *International Journal of Production and Operations Management*, Vol. 13, No.1

Neely A, 1996, *Getting the Measure of your Business - workbook*, University of Cambridge

New C, 1992, World-class manufacturing verses strategic trade-offs, *International Journal of Operations and Production Management*, Vol. 12, No. 6, pp. 19-31

P

Parnaby, J, 1987, Concept of manufacturing system, *International Journal of Production Research*, Vol 17, No. 2, pp123-135

Peters T, 1987, *Thriving on Chaos*, Alfred Knopff, NY

Pisano G P, Wheelwright S C, 1995, The New Logic of High-Tech R&D, *Harvard Business Review*, September-October, pp. 93-105

Plenert G, 1993, An overview of JIT, *International Journal of Advanced Manufacturing Technology*, pp. 91-95

Plowman L, 1989, Learning from learning theories: an overview for designers of interactive video, *Interactive Learning International*, Vol.5., pp. 165-174.

Pressman R S, 1992, *Software Engineering: a practitioners approach*, (3rd Edn), McGraw-Hill

Price Waterhouse, 1991, *Small Firms Guide*

Ptak C A, 1991, MRP, MRPII, OPT, JIT, and CIM - succession, evolution, or necessary combination, *Production and Inventory Management Journal*, second quarter, pp. 7-11

R

Reigeluth C M, Stein F S, 1983, The Elaboration Theory of instruction, In (Ed) Reigeluth, C.M., *Instructional design theories and models: an overview of their current status*, Hillsdale, NJ: Lawrence Erlbaum Associates

Reisman A, 1988, On alternative strategies for doing research in the management and social sciences, *IEEE Transactions on Engineering Management*, Vol. 35, No. 4, November, pp. 215-220

Rodden T, 1991, A technical framework for CSCW, in IEE, 1991, Colloquium on CSCW: some fundamental issues, Computing and Control Division, March

Rynning M, 1992, Successful Consulting with Small and Medium-sized vs. Large Clients: Meeting the Needs of the Client, *International Small Business Journal*, vol 11, No 1, October-December

S

Savage C, 1990, *Fifth Generation Management: Integrating Enterprises through Human Networking*, Digital Press, Bedford, MA

Safayani F, Purdy L, van Engelen R, Pal S, 1991, Difficulties of JIT implementation: a classification scheme, *International Journal of Operations and Production Management*, Vol. 11, No. 7, pp. 27-36

Schein E H, 1983, The role of the founder in creating organisational culture, *Organisational Dynamics*, Summer, pp. 13-28

Schein E H, 1984, Coming to a new awareness of organisational culture, *Sloan Management Review*, Winter, pp. 3-16

Schein E H, 1987, *Process Consultation: Its role in organisation development*, Vol.1. (2nd Edn.), Addison-Wesley

Schein E H, 1993, How can organisations learn faster? - the challenge of entering the green room, *Sloan Management Review*, Winter, pp. 85-92

Schonberger R J, 1986, *World Class Manufacturing - the lessons of simplicity applied*, The Free Press, NY

Schonberger R J, 1990, *Building a Chain of Customers*, The Free Press, NY

Senge P M, 1990a, *The fifth discipline - the art and practice of the learning organisation*, Doubleday.

Senge P M, 1990b, The leaders new work: building learning organisations, *Sloan Management Review*, Fall, pp. 7 -23

Sharan Y, Sharan S, 1992, *Expanding cooperative learning through group investigation*, New York: The Teachers College Press

- Shneiderman B, 1992, *Designing the User Interface: strategies for effective human-computer interaction (2nd Edn)*, Addison-Wesley
- Skinner C, Pearson J R W, 1993, *Business Process Re-engineering in the UK Financial Services Industry*, Highams Systems Services Group Ltd, UK
- Smart P A, Maull R S, Childe S J, Weaver A M, Bennett J, 1996, Specification of a Business Process Re-engineering Methodology for Small and Medium sized Manufacturing Enterprises, working paper WP/GR/J95010-10, University of Plymouth
- Smith S, Tranfield, D, Whittle S, Martin V, 1994, Changing Manufacturing Paradigm: a thematic approach, 4th International Conference on Human aspects of Advanced Manufacturing and Hybrid Automation proceedings, UMIST, Manchester, July
- Soh C, Yap C, Raman K, 1992, Impact of Consultants on Computerisation success in Small Businesses, *Information and Management*, pp. 309-319
- Spencer K, 1991, Modes media and methods: the search for educational effectiveness, *British Journal of Educational Technology*, Vol.22, No.1, pp. 12-22
- Staughton R, Williams C, Hill T, Westbrook R, 1996, Why Consultants fail UK SME's: data and opinion, *Proceedings of the 3rd International Conference of the European Operations Management Association*, London, 2-4 June 1996
- Susman G I, Evered R D, 1978, An assessment of the scientific merits of action research, *Administrative Science Quarterly*, Vol. 23, No. 4, pp. 582-603
- Sutcliffe A, 1988, *Human-Computer Interface Design*, Macmillan Computer Science Series, Macmillan, Basingstoke
- Sweeters W, 1994, Multimedia electronic tools for learning, *Educational Technology*, May/June, pp. 47-52
- T**
- Teaching Company Directorate (TCD), 1995, TCS Centres for Small Firms: Guidelines, June
- Teece D J, Pisano G, Shuen A, 1992, Dynamic capabilities and strategic management', Harvard Business School working paper
- Thomas K W, Tymon W G (Jr), 1982, Necessary properties of relevant research: lessons from recent criticisms of organisational science, *Academy of Management Review*, Vol. 7, No.3
- Thomson V, Graefe U, 1989, CIM - a manufacturing paradigm, *International Journal of Computer Integrated Manufacturing*, Vol. 2, No. 5, pp. 290 - 297

Tollhurst D, 1995, Hypertext, hypermedia, multimedia defined, *Educational Technology*, March-April, pp. 21- 26

V

Voss C A, 1984, Production/Operations Management: a key discipline and area for research, *Omega International Journal of Management Science*, Vol. 12, No. 3, pp.309-319

Voss C A, Robinson S J, 1987, Application of just-in-time manufacturing techniques in the UK, *International Journal of Operations and Production Management*, Vol. 7, No. 4, pp. 46-52

Voss C A, Blackmon K, 1994, Practice performance relationships in UK manufacturing industry, Proceedings of the 1st International Conference of the European Operations Management Association, University of Cambridge, 27-29 June, pp. 1-6

W

Weaver, A M, 1995, A Model Based Approach to the Design and Implementation of Computer Aided Production Management Systems, PhD Thesis, University of Plymouth

Welsh J, White J, 1981, A Small Business is Not a Little Big Business, *Harvard Business Review*, vol 59, No 4, pp. 18-32

Welsh T M, Murphy K P, Duffy TM, Goodrum D A, 1993, Accessing elaborations on core information in a hypermedia environment, *Educational Technology Research and Development*, vol 41, No 2, pp. 19-34

Whittle S R, Smith S, Tranfield D, Foster M, 1992, Benchmarking: the downside of best practice, *Proceedings of the 7th International Conference of the Operations Management Association*, UMIST.

Womack J P, Jones D J, Roos D, 1990, *The Machine that Changed the World*, Rawson Associates, NY

Wortmann J C, 1990, Towards One-Of-A-Kind Production: The Future of European Industry, *Advances in Production Management Systems*, Elsevier Science Publishers, Holland

APPENDIX 1

Responses from SME workshop

Issues Inhibiting Change in Small and Medium Sized Enterprises

A workshop was conducted with representatives from small and medium enterprises to discuss the factors which tended to inhibit change in their companies. Attendees of the workshop were split up into groups denoted by the type of company they represented. This categorisation is based on the work by Mount et al (1993) and include the categories: Owner Operated, Transition to Owner-Managed, Owner-Managed, Transition to Emergent-Functional, and Functional. Companies selected their appropriate group themselves with little assistance from the facilitators.

Following a brief presentation on BPR, the research question was posed: '*What are the problems associated with introducing change in your Company?*'. On receipt of this question the workgroups were asked to brainstorm answers to this question based on their own particular experience. Members of the research team sat in on these sessions but only intervened to provide triggers to other possible areas of consideration. Following the generation of ideas, the groups were asked to group the issues. The following sections illustrate the results which were obtained.

1. Owner Operated/Transition to Owner-Managed/Owner-Managed.

1.1 Managing Director

- M.D. is the Company
- Change depends on MD's background, perception, goals.
- No big term vision
- Don't want to grow too big.
- Director will not relinquish control
- Does not like the idea of change - risk.
- Lack of commitment to change
- Justification of committed time.
- Two owners cause conflict.
- Lack of commitment to project - MD boredom
- The MD developed the existing system.

1.2 People

- Craft or academic background - may not be prepared to think.
- No overview of whole company
- Employees cannot always see the bigger picture.
- Threat of employees setting up rival businesses.
- Manager/employer relationships.
- History of company - length of service
- Personal identification with current practice.
- Protective of current practice.
- Suspect of modern management techniques.
- Educating the people.

1.3 Financial

- Short term goals
- Not worried about payback.
- Financially justifying the planning process.
- Lack of accounting procedures
- Difficulty in investing in change.
- Lack of access to information.

1.4 Time

- Directors have no time to be involved or organise change.
- Owner under time pressures.
- Time to make change - justification of reward.

2. Transition to Emergent-Functional

2.1 Hard Facts

- Lack of time.
- Lack of funds.
- Awareness of IT.
- Understanding capabilities of IT.

2.2 People Factors

- Lack of common objectives/interpretation.
- Lack of faith in technology (GIGO).
- If it ain't broke, don't fix it.
- No vision of future
- Previous bad experience.
- Resistance to new ways of working/fear of the unknown.
- Not seeing immediate benefits.
- Clash of personality between functions.
- Attitudes
- Excited about using new technology (**this is not a problem**)
- Worries about redundancy from technology.
- Fear of new technology.
- Unwilling to share resources/data - 'knowledge is power'
- No methodology to achieve required vision.

2.3 Skills/Training

- Skills to do new activity
- Skills to analyse business.
- Project management skills
- Ability with technology.
- Lack of training in new methods e.g. Computers

3. Functional

3.1 Resources

- New building may be required for a new plant layout (resources)
- Short term views.
- Time required for change.
- Lack of structure in place for re-training programmes.
- The way of redeploying resources.
- More resources required to implement changes.
- Lack of knowledge/re-training

3.2 People

- Top down support - involvement from all levels.
- Power of persuasion
- Imposition of ideas does not work.
- Increase in money/remuneration to implement changes.
- Attitude - don't like change.
- Marketing of changes.
- Knowledge is power.
- Peoples perception of change.
- Selling changes to process operators.
- Insecurity of job resulting from change.

3.3 Business Overview

Drops in productivity levels during change periods.
Acquisition of process knowledge to implement changes.
Culture clashes.
Have to measure current position to benchmark after change.

3.4 Technology

Common IT system.
New technologies may be utilised as long as expertise and money are available.
The need to adopt IT such as EDI.

3.5 External Pressures

Customer reactions to changes.
Trade unions.
Business regulations (procedure changes)

APPENDIX 2

Additional projects

Companies and Projects

Superwinch Ltd. - Facilitation of process modelling of the Warranty and Service/Repair process.

WED Ltd. - Process modelling of the order fulfilment process and delivery of IDEF0 modelling course.

Rigibore Ltd. - Discussions regarding the development of an object oriented design system.

Other companies involved in validation, review and discussions include:

Circuit Consultants Ltd

VSW Ltd

Corsair Manufacturing Ltd

Appor Ltd

Eltek Ltd

BAeCAM

Coopers and Lybrand

PE Consulting Ltd

MI Engineering Ltd

APPENDIX 3

Conceptual model of the synthesis of prototypes

Prototypes

Prototype 1 STRATAGEM	Prototype 2 PROFIT	Prototype 3 BPR Tool
<p>Methodology Encapsulation Systematic structure</p> <p>Goal oriented</p> <p>Tools and techniques Skills transfer Task accomplishment</p> <p>Decision support Consensus building</p> <p>Project management Process diary Participant schedule</p> <p>Group working Off-line workshops</p>	<p>Methodology Support Systematic structure</p> <p>Goal oriented</p> <p>Tools and techniques Skills transfer Task accomplishment Experimentation Contextual learning</p> <p>Decision support Consensus building</p>	<p>Exploratory Learning Environment</p> <p>Multi-layered node and link architecture Abstraction / decomposition (Elaboration theory)</p> <p>Learning oriented</p>



Framework of Features

Structured project managed approach
Process methodology (encapsulation or support)
Goal based
Tools and techniques for:
 learning, experimentation, accomplishment of tasks
Support for consensus building and decision making
Exploratory learning environments for transfer of
complex best practice concepts

PUBLICATIONS

THE USE OF COMPUTER BASED BEST PRACTICE DELIVERY MECHANISMS IN EDUCATION

P.A. Smart and Professor D.R. Hughes

Abstract

This paper reports the results of research aimed at the development of computer based tools to deliver 'best practice' to small and medium sized manufacturing enterprises (SME's). The research led to the development of a methodology which takes SME's through a structured improvement process whilst, at the same time, educating company personnel in the concepts tools and techniques essential to success. From this latter work the development of a computer based tool to support undergraduate education is reported.

The CBT Tool and methodology makes extensive use of recent research findings which have highlighted the importance of securing the full involvement of people at all levels in a company in the improvement process. Only in this way can companies fully ensure that staff own and commit to the solutions developed. Recognising that significant and sustainable improvements in performance cannot be achieved without a fundamental rethink of the business the methodology, supported by a simple to use, easy to understand CBT Tool provides the strategic context in which this rethink can take place. Drawing extensively on the lessons of international manufacturing best practice the methodology incorporates well proven tools and techniques to guide companies through the improvement process.

In addition, to offering the opportunity to secure significant improvements in company performance, attention is focused on the role of the CBT Tool in educating and developing company staff. The nature and extent of the

learning process is described explaining the rationale for partitioning activities between the CBT Tool and company staff.

In using the methodology and CBT Tool with undergraduates the approach makes extensive use of role playing in carefully designed workshops to generate contributions, make decisions and agree actions. Because many of the decisions are complex and judgmental the most effective action can only be determined by generating a wide range of contributions from the individuals involved. All are encouraged to feel they have a valid contribution to make. The process is made more productive and effective by the assignment of carefully tailored preworks to be completed prior to each workshop session. To assist in completing prework activities detailed information is provided in the form of Toolkits and proformas which can be used to collect and analyse data.

The use of the CBT in three alternative modes for undergraduate teaching are described; interactive in *Tutorial mode* where the Tool is able to adapt its instructional sequences to the needs of the learner, *Tool mode* - when functioning in this mode, it is not instructing, but educating the learner by enabling a hands-on learning activity, and finally *Tutee mode* - where the learner is able to exercise full control of the computer.

Introduction

In order to provide a mechanism for delivering knowledge of best practice to company staff or undergraduate and postgraduate students one must start by first defining what is meant by the term "best practice".

Best practice

Although a number of authors have emphasised the importance of adopting best practice to regenerate business and advocated its adoption as almost a universal panacea few have attempted to define precisely what it means. A useful starting point is to clarify what is understood as 'best' and 'practice'. An analysis of the individual terms which make up the phrase 'best practice' revealed the following (Oxford English Dictionary, Cambridge English Dictionary):

Best: applicability within a certain category or in certain circumstances, comparison with all others.

In addition it was reasonably deduced that best does not imply perfection. The underlying notion is one of comparison with all others in a sufficiently homogeneous set to make comparisons meaningful. With regard to **all** others, this may prove impractical in practice. It is also important to note that none of the definitions examined states or even implies that what might be considered to be 'best' cannot be improved upon.

Practice: a physical action or activity of some kind, repeating or pursuing an action.

Clearly, then 'practice' is not theory. It has a physical manifestation, this is not to suggest that the activity or action is unconnected or unsupported by theory, but in so much as it relates to theory, it is applied theory.

The delivery of best practice

Essentially, in practice, this means the delivery of *knowledge* relating to best practice. Traditionally such knowledge has been "transferred" by consultants to their clients in the form of advice or assistance in diagnosing company needs, identifying appropriate best practice to meet the needs and assistance in implementing the best practices identified.

Unfortunately, whilst larger and medium sized businesses may already have, or be in a position to buy in required expertise small businesses are known to suffer from resource poverty. Resource poverty is characterised by immense constraints on financial resources, a lack of human resource expertise, and a short range management perspective imposed by a volatile competitive environment (Ibrahim and Goodwin 1986).

Other means by which small companies can acquire knowledge of best practice include attendance at seminars and conferences, television, trade and popular press, technology vendors, books and workbooks, each of which have significant drawbacks.

Attendance at conferences and seminars rarely provides the depth or detail required to inform appropriate action and can be best considered only as raising awareness of best practice. Whilst raising awareness is an essential first step it does not provide an appropriate framework for a coherent programme of action. The same rationale can be applied, to a greater or lesser degree, with respect to articles in the trade or popular press and television programmes.

Vendors of technology not surprisingly suffer from problems of bias, of seeing the clients problems in terms of their technical solutions. Apart from the significant problem of bias the current ethos in manufacturing argues for a focus on simplification, before automation and integration and thus mitigates against the acquisition of best practice via this route.

However, books and in particular workbooks can provide valuable awareness and instructional material. Their availability and relatively low cost provides a reasonable opportunity to acquire knowledge of best practice, especially for those smaller firms restricted by the lack of resources. Methods and techniques may be transferred to the reader/learner of the literature in the form of frameworks used for analysis, supported by relevant case study results to relate those techniques to a comprehensible situation and environment.

Process methodologies, in workbook format, seem to at least fulfil some of the requirements for transferring knowledge of best practice to the target audience. However, though accessible, such materials at best provide a static, predominantly textual mechanism for the delivery of best practice knowledge. Their static nature is unlikely to provide instruction in the practically based, applied methods frequently found in manufacturing regeneration. This is supported by the perceived deficiency of textually based exploded diagrams found in technical manuals, the objective of which is to illustrate the assembly/disassembly of component parts.

In addition, books or workbooks are restricted in the nature of the support they provide lacking the means for automatic calculation, the ability to update, maintain and disseminate information, facilitate analysis and not least facilitate the management of the regeneration process.

Declining costs of computer technology, and the advent of well structured, simple to use designs are influencing more small businesses to use computers (Cooley et al 1987). The use of the computer for the provision of 'interactive' learning provides the possibility to both optimise and facilitate the accessibility of human learning (Gotz 1991). This optimisation is characterised by a number of key attributes:

- A computer assisted learning mechanism may be produced by a team of experts (both in content, presentation and design).
- The learner may designate the time and place for the learning interaction to take place.
- Advanced mechanisms offer varying paths of instruction depicted by a self assessment of possessed skill by the learner.
- The learner may request the assistance of help modules to provide support in the learning module.
- Classification of test results may be integrated into the delivery mechanism.
- The learning sequences may be repeated as often as is needed and may take place directly at the workplace when and where a learning need arises.

In addition to these attributes, the dynamic nature of the computing medium and the recent technological advancements and capabilities provide the potential for a learning environment to be created which far surpasses the boundaries of traditional linear computer based training mechanisms (Houldsworth 1992). The advent of 'multi-media' and the use of both animation and simulation techniques for the transfer of practical knowledge enables an environment to be created which may represent the reality of the learners environment, thus facilitating comprehension of complex activities.

Securing the full involvement of people

Considerable recent research has highlighted the value of securing the full involvement of company staff in any improvement process. Without such support it is debatable whether or not any improvement programme can succeed. This ethos puts company staff at the forefront of the improvement process making all of them responsible, and not their consultants, for the success of the business. Such a philosophy arguably mitigates against the use consultants and highlights the need to develop existing internal expertise. To achieve the best results staff should be involved at the earliest possible stage so that their knowledge and experience can be fully harnessed.

Feasibility and desirability

Two major considerations arise from the above in terms of the nature and scope of the CBT required. First, the need to train staff in the new techniques, technologies and tools (best practice) so they may fully contribute to the success of the company. Secondly, to support staff in managing and making the necessary decisions and undertaking the types of tasks required in a regeneration programme. This latter issue leads inevitably to decisions on which tasks should be carried out by the CBT and which should be undertaken by company staff.

Partitioning tasks between the CBT and the user

A decision was taken to only use the CBT to manage the regeneration programme, perform any required analysis and to maintain and update information and for management development and training. Quite deliberately it was felt vital that the role of company staff was to weigh and judge the information presented to them and collectively arrive at some consensus on an appropriate course of action. The CBT was not allowed to make decisions.

Dual role of the CBT

An important characteristic of the methodology developed is its ability to not only offer the opportunity to secure significant improvements in company performance, but to use the CBT Tool in educating and developing company staff. Consequently, the Tool, via a tutorial facility whilst providing detailed instruction on the content and structure of the regeneration methodology also provides instructions on the use of the individual tools and techniques contained in the methodology. This capability enables users to learn about the techniques without affecting the company's programme of improvement.

Use of the Tool for education and development

Little attempt was made to compare computer based training methods with those traditionally used in human to human interactions. (Clark 1983), suggests that there is no theoretical reason for comparing computer and traditionally delivered instruction. But advocates the benefits for comparing instructional designs themselves. "As a field, it has finally been accepted that

technologies do not mediate learning. Rather, knowledge is mediated by the thought processes engendered by technologies." Therefore, when attempting to use technology as a delivery mechanism to stimulate learning the primary focus is placed on the instructional designs that result in the most productive thought processes. Learning is therefore more directly affected by the soft technologies than it is by the hard technology.

In contrast, a number of studies (Kearsley et al 1983, Kulik et al 1980, Kulik et al 1983, Kulik et al 1984) have compared computer based with more traditional methods of instruction, where significant improvements in learning from computer assisted instruction (CAI) prevailed. However, the popularity of CAI, as a new technology may have stimulated much enthusiasm which would doubtlessly contribute much to its relative effectiveness (Jonassen 1988). The reasons that Clark (Clark 1986) writes for confounding the success of CAI packages (Courseware) are that the amount of instruction, method and content were uncontrolled. This is suggested to be due to the deficiency of the instructional design for producing such courseware and not to the technology itself.

A most useful and lasting taxonomy of educational computer applications is that suggested by Taylor (Taylor 1980). He places the use of computers for this purpose into three categories: Tutorial, Tool and Tutee.

(i) Tutorial - This category involves a high degree of interactivity from the users, a focus is on the learning needs of the recipient thus requiring the instructional sequences to adapt as the learning need changes. This may be achieved by altering both pace and content to fit the learners requirements, and via the provision of alternative levels of difficulty, or items of interest.

(ii) Tool - The objective of the tool mode is to supply a mechanism in which the user may accomplish a task more efficiently and effectively. When the computer is functioning in this mode, it is not instructing, but educating the learner by enabling a hands-on learning activity.

(iii) Tutee - In this mode the user controls the computer. Most of the functions include programming languages or translators which the user instructs to achieve a desired task. Thus, the learner uses the computer to solve a particular problem. In order to achieve this a more comprehensive understanding of the particular problem is required. This itself constitutes a learning activity.

Bentley (Bentley 1992) suggests learning is conducted via direct interaction between ourselves and our environment, and that, learners know 'how to learn'. This concept therefore makes possible the provision of a computer based environment which enables the recipient to learn in their own 'personalised' way.

The use of a computer based tool for teaching may be viewed as following two of the three paths suggested by Taylor (Taylor 1980). First, the provision of 'tools' which enable the learner to conduct experimental learning (Bentley 1992).

For example, a module was designed which provided a tool for the learner which was based on environmental scanning and stakeholder concepts. Providing a 'tool' in this way enforced that the learner consciously took an holistic view of the relative performance of the key stakeholders (customers, competitors, suppliers) in the context of the business information supplied.

In addition, support must be provided for this method of learning. Information was supplied in a set of 'tutorial' style modules which provided the background knowledge and context for the objective of the tool. This included the provision of information on: origin, rationale and supported worked examples directly relating to the experimental learning exercise presented in the tool mode. This information was stored in varying degrees of complexity where each item of information would have associated items based on the following criteria: possibly of interest, probably of interest, more specific, more generic (Bentley 1992).

Furthermore, the identified 'best practice' was partitioned into discrete modules to facilitate the comprehension of its content and provide visible goals to enhance the motivation of the learner.

Conclusions

The paper has presented a number of considerations necessary for effectively delivering best practice to both industry and under graduate student. The utilisation of technology provides a formidable opportunity for instigating learning experience in a number of circumstances. This include: cost, time and safety considerations to mention a few. In addition, the approach presented attains a direct compatibility with the ethos of making companies responsible for the emerging activities relevant to successful business improvement. This concept is further supported by the identification of the need to involve personnel in the learning/educational process and by their participation in judgmental decision making. The approach focuses on the importance of the instructional design of such mechanisms to mediate

learning in the intended target audience as opposed to a focus on the capabilities of the hard technologies.

References

Bentley, T., (1992), *Training to Meet the Technology Challenge*, McGraw-Hill.

Clark, R. E., (1983), Reconsidering Research on Learning from Media, *Review of Educational Research*, 53, 445-460.

Clark, R. E., (1986), Research on Student Thought Processes During Computer Based Instruction, *Journal of Instructional Development*, 8(3), 2-6.

Cooley, P. L., Waltz, D. T., and Waltz, D. B., (1987), A Research Agenda for Computers and Small Business, *American Journal of Small Business*, 12, (3), 31-42.

Gotz, K., (1991), Interactive Learning with the Computer, *Educational Training and Technology International (ETTI)*, 28, (1), 7-14.

Houldsworth, E., (1992), Technology Based Training as a Potential Aid to Competitive Advantage: A Survey of Small and Medium Enterprise & Training and Enterprise Councils, *Working Paper Series, Henley Management College*.

Ibrahim, A.B. and Goodwin, J.R., (1986), Perceived Causes of Success in Small Business, *American journal of small business*, 41-50.

Jonassen, D. H. (Ed) (1988), *Instructional Designs for Microcomputer Courseware*, Lawrence Erlbaum Associates.

Kearsley, G., Hunter, B., and Sidel, R. J., (1983), Two Decades of Computer Based Instruction: What We Have Learned?, *THE Journal*, 10, 88-96.

Kulik, C., Kulik, J., and Bangert-Drowns, R., (1984), Effects of Computer Based Education on Secondary School Pupils, Annual American Educational Research Association Meeting, New Orleans.

Kulik, J., Bangert, R., and Williams, G., (1983), Effects of Computer Based Teaching on Secondary School Students, *Journal of Educational Psychology*, 25, 19-26.

Kulik, J., Kulik, C., and Cohen, P., (1980), Effectiveness of Computer Based College Teaching: A Meta-Analysis of Findings, *Review of Educational Research*, 50, 525-544.

Taylor, R., (1980), *The Computer in Education: Tutor, Tool and Tutee*, New York: Teachers College Press.

D. R. Hughes, P.A. Smart and S. White

*Centre for Research in World Class Manufacturing
University of Plymouth, UK*

Abstract

The paper describes the results of a survey undertaken to assess the relative performance of UK manufacturing companies. The survey revealed that whilst considerable improvements in competitiveness had been achieved for many companies much still remained to be done to match the performance of our best international competitors. Using criteria associated with business performance, market needs and operational performance, relevant comparisons were drawn where possible between large and small manufacturing companies. Surprisingly the results revealed little evidence of significant differences in overall business performance, market needs and priorities for investment.

Introduction

The UK Benchmarking Survey carried out by BAe CAM and the University of Plymouth (Hughes et al, 1993) received responses from 177 manufacturing enterprises involving almost 50 industrial sectors and a combined turnover in excess of £4bn. Respondents represented a sizeable proportion of UK manufacturing industry. Although the sample could not be considered to be statistically valid it did meet the primary objective of facilitating comparison between groups of companies operating in the same, or sufficiently similar, sectors to allow meaningful conclusions to be drawn.

This paper contains sample wide analyses and trends based on the data received from all participants. To facilitate certain analysis a distinction has been made between large and small companies on the basis of the **number of employees**. With regard to small companies the number of employees has been set to a maximum of 250, in line with the definition currently being adopted within the EEC. Large companies are defined as having more than 250 employees.

As space does not permit the full results of the survey to be included data relating to business performance, in terms of revenue and value added per employee, market needs, the respondents perceptions of their shortfall in meeting the needs and certain aspects of operational performance are presented.

Considerable **improvements in competitiveness** have been achieved, however much still remains to be done to match the performance of our best international competitors.

The **average figure for value added per employee of £25,000** is far below that of our international competitors who report average values ranging from £35,000 to £80,000. Most UK companies still need to make considerable improvements.

However, some **small companies** achieved over £120,000 per employee for value added, matching the figures achieved by some of the best companies in the world.

The **low levels of revenue per employee** (below £30,000), recorded by eight percent of the sample must be a significant cause for concern.

Companies experienced most **difficulty** in meeting their customers cost requirements with the shortfall in performance being twice as great as that of meeting their quality requirements.

Spending on **new product development**, at just under 3% is less than half the proportion spent by the most successful overseas manufacturing companies.

The **unhealthy measurement** of performance based on machine utilisation is diminishing. Unfortunately, measures which most closely relate to the market and customers needs were chosen by the least number of companies.

20% of companies concluded that **Materials Requirements Planning (MRP)** had not improved their performance and many companies had withdrawn it.

A surprisingly high number of companies, almost two thirds, regarded their **Master Production Schedule (MPS)** as unstable.

The major **causes of instability** were external, customer changes, rush orders and market fluctuations highlighting the need for adoption of short lead time manufacturing and rapid customer response systems.

Significant **reductions in lead times**, an average of almost 40%, with a 10% reduction in costs have been achieved through Cellular Manufacturing.

Business Performance

Value added and revenue per employee

Surprisingly there was very little difference in both value added and revenue per employee for large and small companies. However, although the average value remains almost identical at £25,000 and £62,000 respectively there is a difference in the distribution of revenue per employee and a significant difference with respect to value added per employee with smaller companies dominating the extreme high and low values.

Some small companies achieved figures for value added in excess of £120,000 per employee. This is comparable to the standard of performance being achieved by some of the best companies in the world. However, the average figure of £25,000 is far below that of our international competitors. A number of recent surveys reveal average values ranging from £35,000 to £80,000 demonstrating that most UK companies still have far to go.

The low levels of revenue per employee (below £30,000), recorded by eight percent of the sample must be a significant cause for concern.

Annual project spend

The greatest proportion of annual spend was on plant and equipment representing just over 4% of turnover. The second, new product development, at just under 3% is less than half the proportion spent by the most successful overseas manufacturing companies. The Centre for Research in World Class Manufacturing at The University of Plymouth recently examined ten Japanese electronics manufacturing companies and found that between 6% and 14% of turnover was spent on new product development. (Culverhouse, 1992)

Market Needs

Achieving business requirements

The results of the survey highlighted the shortfall between what the companies surveyed believed their own performance to be and what they believe are their customers requirements. Most difficulty was experienced in meeting customers cost requirements. The shortfall in performance here was twice that of meeting quality requirements. To some extent this reflects increased competition in the market and the recent poor trading conditions. Arguably, though the results provide further evidence that quality is no longer regarded as the critical component of competitiveness.

Customers now rightly expect that the required standards will be met and the real battleground is on cost and delivery.

Relative importance of leading issues

Both large and small companies had the same view on their priorities. Both regarded IT and management information as the least important and cost reduction and customer service as the most important. Care should be taken in interpreting this result. The general lack of importance assigned to IT and management information may reflect the fact that many companies now feel that these have been resolved and consequently, are no longer a concern.

The importance attached to the development of new products and markets is probably a response to increased competition in difficult trading conditions. This is supported by the results obtained from a joint UK, Swiss and German survey carried out six months earlier (Maull et al, 1992a), clearly indicating that the concerns are similar throughout Europe.

The importance given to cost reduction reflects the need to address the perceived shortfall in performance identified earlier and the current difficult trading conditions.

Choice of performance criteria

The survey demonstrated that the unhealthy measurement of performance based on machine utilisation is diminishing. Unfortunately, the use of customer service level criteria, which arguably is the most closely related to customers needs was chosen by the least number of companies. The emphasis on internal rather than external criteria compares badly with the measures adopted by most world class performers. World class companies focus on customer service and regularly monitor their performance on price, quality, delivery and customer service by undertaking frequent customer surveys and by Benchmarking their performance against other companies. If performed correctly this provides the most accurate information direct from the customers themselves, of the performance of their products and services

The most popular choice of respondents was the use of internal schedule adherence criteria. Whilst this is useful in ensuring the timely and ordered completion of work it does not necessarily reflect good due date performance (service levels). It is often the case that significant improvements in the factory are negated by poor performance in sales order processing, purchasing, warehousing, dispatch and delivery. Indeed increasing recognition of the large savings in lead times available in these areas is driving the upsurge of interest in concurrent engineering and business process redesign (Maull et al, 1992b).

Master Production Schedule

Only 37% of respondents who have a Master Production Schedule believe it to be stable. The major causes of instability were regarded as external, customer changes 27%, rush orders 19% and market fluctuations 19% and forecast error, 14%. Accepting that some of these instabilities are beyond a companies direct control and yet must be accommodated argues strongly for the adoption of short lead time manufacturing and rapid customer response systems. Such a strategy would not only address external causes of instability but is likely to prove effective in responding to all the reasons for MPS instability whilst at the same time considerably improving overall competitiveness.

MRP usage and effect on manufacturing performance

41% of the companies had implemented an MRP system. Excluded from the value shown for MRP usage is a sizeable number of companies who had implemented MRP but who had subsequently withdrawn their system. An MRP usage value in excess of 50% would have been derived if these had been included.

The survey revealed that only 81% of respondents using MRP claimed that it had improved their performance. Surprisingly, 15% claimed it had no effect and 4% claimed it had actually made things worse. The factors regarded as major contributors to failure were unrealistic master production schedules, poor data accuracy and a general lack of understanding. Unrealistic master production schedules can be attributed mostly to external factors. However, the other factors such as lack of resources, scheduling of resources and failure to take into account backlogs are internal problems and manageable by the companies themselves.

The survey revealed an increasing take up of cellular manufacturing with 47% of the companies surveyed having implemented cells. A number of respondents reported planned to either implement cells or increase the existing number of cells indicating that the usage of cells will increase dramatically in the future.

The results revealed significant reductions in lead times, an average of almost 40%, were reported with a 10% reduction in costs. The lower level of cost reduction as compared to the dramatic reductions in lead time perhaps reflects the fact that the use of cellular manufacturing is aimed at improving customer response time and is not machine utilisation and labour optimisation driven.

The lower level of cost reduction may also prove to be deceptive. Many current costing systems are not appropriate to monitoring and collecting costs in the revised cells and therefore, many companies do not really know what is the true cost position.

Conclusions

The results demonstrate that whilst considerable improvements in competitiveness have been achieved by many UK companies much remains to be done.

A number of small companies outperformed larger UK companies matching the performance in terms of value added per employee of some of the very best companies in the world. Unfortunately, the performance of a number of other companies both large and small demonstrated that success was extremely patchy - with the survival of some 8% of companies being a significant cause for concern.

There was very little difference between large and small companies in their perception of what their market needs were and which best practices should be implemented. Whilst there is general recognition, at least in outline, of what constitutes "best practice" it is in its implementation that differences can be seen. Whilst larger companies are generally more aware and active in promoting best practice it is smaller companies who often have the most success. The simple analogy of the effort required to turn a super tanker is appropriate.

This should not discourage larger companies who have the most to lose by not improving and the most to gain by staying ahead of the competition. Indeed perhaps there are lessons to be learned by adapting the culture and flatter organisation structures typical of smaller companies.

Cost remains for many companies the most important competitive criteria - far more important than quality. This does not imply that the respondents were unconcerned about quality but most experienced little difficulty in meeting their customers requirements.

Changes in customer requirements highlight the need for short lead time manufacturing and rapid customer response systems. One approach to this problem - cellular manufacturing - demonstrated that significant reductions in lead times, an average of almost 40%, can be achieved.

The spending on new product development, at just under 3% of turnover does not auger well for the future. As product life cycles shrink and customers become more demanding of their suppliers UK companies must respond or see their markets plundered by their overseas competitors.

To respond to this challenge UK companies need to remain close to their customers. Anticipate rather than respond to changes in their markets and, not least, they must harness the full potential of their people to contribute to the business through the generation of product and process improvements.

In turn this requires Directors with the vision to recognise opportunities, the experience to understand business needs and the skills to communicate their vision and plans to all employees so that they can own, commit and contribute to the improvement process.

References

CULVERHOUSE, P. F. BENNETT, J. P. R. and HUGHES, D. R. (1992) "Electronics Product Development Practice - East versus West", 8th International Conference on CAD/CAM, Robotics and Factories of the Future, Metz, France, Metz. ISPE 67-81

HUGHES, D. R. SMART, P. A. and WHITE, S. (1993) "UK Benchmarking Survey", BAe CAM / University of Plymouth, Plymouth.

MAULL, R. S., BENNETT, J. P. H. and HUGHES, D. R., (1992a) MAESTRO "Management Evaluation of Strategic Options", 7th International Conference of Operations Management Association, Manchester, UK, Amsterdam: North Holland, 63-71

MAULL, R. S., CHILDE, S. J., HUGHES, D. R., TRANFIELD, D., SMITH, S. (1992b) "Themes and Vision in the Regeneration of Manufacturing Competitiveness", Robotics and Factories of the Future, Metz, International Society for Productivity Enhancement, 1467-1476

D. R. Hughes and P.A. Smart

*Centre for Research in World Class Manufacturing
University of Plymouth, UK*

Abstract

This paper discusses "best practice" as applied to manufacturing industry. Recognising that what might be considered as 'best practice' for one company may be entirely inappropriate to another the identification of different types of best practice, generic and situational, are explored. From this a definition of best practice is presented defining precisely what it means, how it can be determined, by whom and its relevance to competitiveness as exemplified by the concept of World Class Manufacturing. The paper concludes by proposing guidelines on how 'best practice' should be determined and by whom.

Best Practice

Current literature in manufacturing is awash with the term "best practice". Writers in the areas of 'benchmarking' (Camp, 1989), (Mortimer, 1993), and Quality, Dale and Tidd, 1991) together with various Department of Trade publications recognise the importance of adopting 'best practice' for corporate growth and survival. Camp (1989) argues that traditional target setting methods have failed US managers and 'blind sided' them to the competition. He claims that superior performance can only be achieved by establishing operating targets and productivity programs based on industry best practices. In addition, in an introduction to the *Managing in the 90's - The Competitive Response* (DTI, 1991), The Rt. Hon Michael Heseltine MP claims:

"The business with the best prospects for long term success seem likely to be those which recognise the need for positive changes, to adapt, to innovate and to plan for continuous improvement and the introduction of best practice into all their activities. Adopting best practice in marketing will help you get closer to your customers. Adopting best practice in design, development and manufacture of improved products will help you exploit the opportunities you identify. Adopting best practice in purchasing will help you make full use of the potential of your suppliers."

Whilst such statements would find considerable support in industry it is extremely doubtful if all industrialists fully understand what the term "best practice" means and how it might be identified. To establish a starting point the authors examined definitions of the individual terms and from this base propose the following definition of best practice for manufacturing:

"An activity which is better than, or equal to the standard of performance being achieved by any other activity undertaken in a sufficiently similar circumstances to allow meaningful comparisons to be made."

Classes of Best Practice

In terms of transferring best practice, experience demonstrates that one is really transferring one or two kinds of knowledge; i) knowledge of a particular best practice and ii) knowledge of how to apply or exploit a best practice in a given situation. The definition adopted above implies that an assessment may only be conducted in circumstances which make meaningful comparison possible. This distinction is highly relevant to the application of best practice to improve competitiveness. Application is only appropriate when circumstances are similar. Whilst, at a detailed level of analysis, no two businesses are alike they may face similar kinds of generic problems and, where sufficient compatibility exists, it maybe be possible to identify industry/sector practices applicable to a wide range of companies. In addition there may also be best practices which relate to certain circumstances and specific functional activities or areas. For example, a PC manufacturer with many customers and distributors make look to a supermarket chain to identify distribution best practice. Consequently, best practices can range from the generic, to industry/sector specific and horizontally across functional areas.

World Class Manufacturing and Best Practice

In order to achieve World Class performance companies must adopt a combination of generic, industry/sector specific and functional best practices related to the key business drivers of the company and the dynamics of their markets. To be World Class companies must learn from others who have achieved best practice - this should be a creative act rather than merely copying, "copying assumes a great many institutional and contextual variables remain constant." [Rose, 1991]. Experience has shown that certain generic best practices are essential to ensure the ongoing appropriateness and continuous improvement of existing operations.

Determining manufacturing Best Practice

In order to identify best practice three things are required, knowledge of the current performance in a particular category or circumstance - what might be expressed colloquially as the "going rate", expertise to evaluate and interpret the knowledge and finally, independence to ensure that judgements made are objective. These factors will now be explored in more detail.

A pre-requisite for determining if a manufacturing activity represents best practice is knowledge of the standards of performance of other companies in the category or circumstances being considered. Such knowledge may be acquired directly or inferred from external information on market performance, financial ratio's or profitability. Having acquired the knowledge of the standard of performance currently being achieved by manufacturers the next step is to interpret and understand the data. This requires expertise on the activity being evaluated so that correct assessments can be on the performance of one company with respect to others in the same category or set. Finally, the judgement of what is best practice must remain untainted by vested interest. It is clearly, therefore inappropriate for an individual or group of individuals who are unbiased and totally independent to make such judgements.

THE USE OF ANIMATED GRAPHICAL SIMULATION TECHNIQUES TO SUPPORT THE SERVICE ENGINEER

David R. Hughes, Philip A. Smart, Richard Stead and Michael G. Wilkinson
Center for Research in World Class Manufacturing
School of Computing, University of Plymouth, Plymouth, PL4 8AA, UK.

ABSTRACT

The results of a research project into the problems confronting the service engineer in repairing and maintaining complex, technologically advanced equipment and systems in a multi-customer, multi-supplier environment are reported. The solution proposed makes use of graphical simulations encapsulated in an electronic performance support system to guide the service engineer through complex assembly and disassembly operations, appraise the engineer of the potential causes of the problems, provide information on service histories, provide analytical tools to facilitate problem identification and solution generation and eliminate much of the drudgery and inefficiency associated with the maintenance and updating of service records.

Focusing specifically, on the graphical simulation techniques employed in IMAS (Interactive Manuals and Servicing) the paper concludes with a case study describing the development and application of an IMAS type system to support the service engineer maintaining equipment and systems in the machine vending industry.

INTRODUCTION

Service Engineers face a number of problems in repairing and maintaining complex, technologically advanced equipment and systems in a multi-customer, multi-supplier environment.

The work load of the Service Engineer in many industrial sectors has increased dramatically in the last few years. Customers require ever shorter response times in an environment where the number, diversity and technological complexity of the equipment, machines and systems are growing rapidly. Rigorous cost reduction exercises undertaken by many companies have further exacerbated the problem by reducing the number of Service Engineers and the amount of stock they are allowed to carry. Consequently, if customer service standards are to be maintained, let alone improved, there is a need to improve the training and support offered to the Service Engineer to achieve the standards of excellence essential for competitive performance.

Unfortunately, whilst the problems in providing service support have been recognised, the degree of support and training required by the Service Engineer has not, in many companies, been addressed. To some extent this can be understood, as training Service Engineer's can be far from easy. Indeed where there is a large range of diverse machines and equipment which need to be maintained and which are subject to frequent change, training the engineer to cover all potential faults may prove impossible by traditional approaches. All but the most general training, not related to specific products may be out of date by the time it is used.

To add to these deficiencies the Service Engineer now faces an increasing range of administrative tasks, the completion of service reports, time sheets, credit notes etc. which further restricts their time. Even though the reporting requirements are often quite onerous, little use is made of the information obtained, as there are no formal means of exchanging information between Service Engineers. Consequently opportunities for sharing information on the types of equipment and systems being maintained and on the problems and solutions encountered is lost. This severely restricts the ability of the Service Engineer to solve problems quickly or acquire the necessary spares prior to the service visit resulting in poor customer service and additional expense.

The absence of a structured, easily accessible information source also presents difficulties for the management of customer service activities. The problems encountered in tracking service history's and part requirements often leads to frequent, non-cost effective ordering, increasing costs significantly. Furthermore, the lack of accurate feedback on problems to the manufacturers of the equipment and systems means that faults may be perpetuated for long periods of time.

SUPPORT FOR FAULT DIAGNOSIS AND MAINTENANCE TASKS

With regard to the nature and extent of the support available to the Service Engineer in carrying out fault diagnostics and maintenance tasks, this is usually in the form of paper based manuals. Unfortunately, due to the diversity of problems and products encountered this

often necessitates several volumes to be carried. In addition to their cumbersome nature, manuals provide a static medium which is generally unsuitable for a field where the majority of knowledge acquisition is obtained from practical experience. This factor severely restricts Service Engineer's ability to change, correct and influence the manuals content or structure, on the basis of their own practical experience.

Where the Service Engineer is dealing with unfamiliar equipment and systems, paper based manuals, which are by their nature static, often prove woefully inadequate. They do not show clearly how the equipment or system operates, nor do they show the integration of various sub-assemblies and parts dynamically. It is in this latter respect that the incorporation of graphical simulation techniques within a coherent Electronic Performance Support System (EPSS) is particularly useful.

ELECTRONICS PERFORMANCE SUPPORT SYSTEMS (EPSS)

Geary (1992) describes Electronic Performance Support Systems as follows:

"An electronic performance support system is an integrated electronic environment that is available to, and easily accessible by, each employee. It is structured to provide immediate individualised on-line access to the full range of information"

Clearly, an EPSS is not just a piece of software or an electronic device it is a concept which explicitly recognises the importance of providing information to those who need it in order for them to carry out their tasks more productively (Bentley 1992). Such a system would do much to alleviate many of the problems of the Service Engineer.

If, within an EPSS framework, graphical simulations are provided to assist the Service Engineer to understand how the equipment or systems to be serviced operate this would offer considerable advantages. Taking this concept further, if additional help was made available in the form of interactive simulations to provide detailed step by step guidance on how equipment and systems should be assembled or disassembled then further benefits would be obtained.

From this it can be seen that the provision of an EPSS incorporating graphical simulation techniques, if practicable, offers a realistic approach to the current problems encountered by the Service Engineer. However, before the feasibility of such an approach can be examined there is a need to define what we mean by the term 'simulation'.

THE ROLE OF ANIMATED GRAPHICAL SIMULATION TECHNIQUES

A simulation is a representation of reality for a particular purpose (Jonassen 1988). It is invaluable where expense or lack of time mitigates against physical development and testing. Simulation can also encapsulate large amounts of time compressed practice and is sometimes the only feasible method for creating certain types of learning experience (Romiszowski 1986). It is in this latter respect that the use of graphical simulation techniques presents significant opportunities to train the Service Engineer in the operation, assembly and disassembly of complex equipment and systems.

Given recent advances in technology, it is now possible to provide high quality graphical representations of reality via lifelike simulations and demonstrations using text, sophisticated graphics and visual media. This enables the user to formulate new concepts or cognitive schemata with respect to a phenomenon or process. This facility greatly extends the commonly recognised capabilities possessed by the electronic computer for manipulating, storing and presenting information.

Because a great deal of learning is done by observation and copying (Bentley 1992), interactive graphical simulation techniques provides an opportunity for the Service Engineer to acquire detailed knowledge about the tasks they are expected to perform.

The integration of these interactive graphical simulation techniques into electronic manuals is described in the following case study.

IMAS CASE STUDY

The results of applying graphical simulation techniques have been tested in the development of IMAS (Integrated Manual and Servicing) application. Development commenced by reviewing an existing parts and service manual related to a vending machine dispensing hot and cold drinks.

Although this application was felt to be relatively simple it did enable the authors to explore ways in which the required service information could be delivered to the Service Engineer by computer in a primarily non text format. In particular the application area enabled a full test of visually animated graphical simulations of system and equipment operation and assembly and disassembly operations to be undertaken and to assess whether this would enhance the Service Engineers performance and improving customer satisfaction.

It had been recognised that the majority of manuals are created on computer based DTP systems and therefore the information would be available in digital format. The methods used to elicit information to generate the content of current manuals and to update them were investigated.

A parallel research activity sought the views of the Service Engineers maintaining the vending machines on the appropriateness of the content and the mode of presentation. This highlighted considerable dissatisfaction with existing paper manuals. In particular, the use of text illustrated by simple line drawings or photographs did not provide the information required to understand, operate, assemble and disassemble the more complex vending systems encountered.

Not surprisingly it became apparent that the more complex the equipment or system to be maintained the less satisfaction there was with paper based manuals. Whilst all insisted that textual information was required, for example part numbers, model numbers, fault history etc. it was not thought to be very helpful in understanding how complex equipment and systems operated.

In order to address this latter need an electronic manual was developed incorporating advanced graphical simulation techniques which were capable of representing the overall operation of the vending machine, together with assembly and disassembly operations at a variety of levels of complexity.

The design concept of the system was based on the following:

- 1 To encapsulate the best knowledge available of the normal operation of the vending machine and to make it available at the time of need.
- 2 To use all forms of digital media to maximise the effectiveness and efficiency of information and knowledge transfer.
- 3 To provide an almost automatic method of capturing accurate fault and remedial information, which could be used to update and improve the manual content as well as the equipment or system itself.
- 4 Information and instruction should be linked to the item under investigation and retrieved via an image of the item, not via an index of part numbers.

- 5 An item in the manual should appear as a virtual model which can be dis-assembled, assembled, calibrated, tested etc. alongside the real item.
- 6 Information should be structured so that varying levels of 'how to' style instruction provide a reminder for the experienced engineer and more detailed a step by step procedures for less experienced Service Engineers.

The mode of presentation developed utilised a variety of complex animation's to simulate the operation of the equipment and was able to illustrate assembly and disassembly operations. The display is enhanced by the use of three dimensional images in a three dimensional space thus giving depth to the usual two dimensional plane, to provide a more visually realistic representation of the actual parts.

Assembly and disassembly simulations were designed so that they could be undertaken under the direct control of the Service Engineer. The system provides the ability for the engineer to select a sub-assembly from a machine view and 'explode' the sub-assembly into its component parts and sub-assemblies.

This process may then be repeated at the next level of detail providing further simulations at greater levels of complexity. This enables the Service Engineer to access information at an appropriate level of complexity when required.

An additional feature of the system developed is its ability to illustrate the overall conceptual operation of the equipment on a two dimensional plane enhanced by animated flows and part movements. For example, in the case of a coffee vending operation, this representation includes a 'brewer' boiling the water, the coffee dropping into the cup, the release mechanism of the cup to its despatch point, and the flow of the boiled water into the cup.

This illustrates a complete cycle of the 'normal' operation of the machine, providing useful information for the Service Engineer prior to undertaking a detailed fault find on the composite parts.

The system developed has been shown to be as effective as sending a Service Engineer on a training course for the equipment. The widespread use of IMAS applications incorporating graphical simulation techniques will have considerable impact on the quality of the Service Engineers performance, together with the opportunity to secure savings from reductions in service time and training costs.

CONCLUSIONS

The problems facing the Service Engineer in maintaining and repairing complex equipment and systems have been identified. A novel solution based on the concept of an EPSS incorporating animated graphical simulation techniques has been identified.

A major benefit of this approach is the ability to provide information 'just-in-time' to the Service Engineer, in a format which closely represents the physical environment. This not only enables a more efficient approach to servicing, but supports standardised training to enable the acquisition of experienced based knowledge, thus saving both time and money.

In addition, the ability to manage and co-ordinate the servicing process via the sharing of information between both managers and engineers and between the engineers themselves enables a more streamlined operation to be adopted.

REFERENCES

- Geary, G. 1992., "The Business of Training." In Training to meet the Technology Challenge, T. Bentley, McGraw-Hill, UK, 85
- Bentley, T. 1992. Training To Meet The Technology Challenge. McGraw-Hill Training Series, Berkshire, UK.
- Jonassen, D. H. 1988. Instructional Designs for Microcomputer Courseware, Lawrence Erlbaum Associates, Hillsdale, N.J.
- Romisowski, A. J. 1986. Developing Auto-Instructional Materials - from programmed texts to CAL and interactive video. Kogan Page, London, UK.

THE DEVELOPMENT AND TESTING OF A COMPUTER BASED TOOL TO ASSIST STRATEGY FORMULATION

D. R. Hughes and P. A. Smart

University of Plymouth, UK

ABSTRACT

This paper reports the results of an intensive 16 man year research programme aimed at developing and testing a methodology to guide businesses through the process of formulating coherent strategies based on international manufacturing best practice.

From an analysis of the inherent difficulties associated with strategy formulation, a methodology is presented which not only guides manufacturing companies through the process of strategy formulation, but also facilitates the transfer of best practice knowledge. The delivery mechanism utilised, a combination of a workbook and a computer based tool, provides the management team with an effective Toolset to reach strategic objectives. Specifically, the methodology developed delivers an agreed corporate mission statement, a strategic analysis of products, markets and competitors, a detailed strategy for controlling systems and processes and concludes with the generation of a set of prioritised action plans for each functional area of the business. The methodology, STRATAGEM, Hughes and Maull [1], is supported by the computer based tool which facilitates management of the strategic regeneration process, and provides relevant tools to aid key decision making.

The paper concludes with a discussion of the use and testing of the methodology with a number of small and medium sized manufacturing companies, focusing particularly on the use of the computer based tool in management development and training.

INTRODUCTION

There has been much concern recently regarding the needs of small and medium sized manufacturing enterprises (SME's), Eyre [2]. The results of two recent research projects one partially funded by the UK's Department of Trade and Industry (DTI), MAESTRO, Management Evaluation of Strategic Options, Maull et al [3],

and a large industrial survey, the UK Benchmarking Survey -1993, (Hughes et al, [4] found that SME's had considerable problems in developing a coherent business and manufacturing strategy and in identifying and applying "best practice".

In order to assist SME's to develop coherent strategies the authors felt that a new approach was required which would enable them to apply best practice in an effective and affordable manner. This was thought essential given the resource poverty of many SME's. Unfortunately, whilst larger and medium sized businesses may already have, or be in a position to buy in the required expertise, many small businesses are characterised by immense constraints on financial resources, a lack of human resource expertise, and a short range management perspective imposed by a volatile competitive environment Ibrahim and Goodwin [5].

The paper outlines an approach which differs markedly from traditional consultancy methods which attempt to 'lock' clients into costly and potentially open-ended relationships. In such circumstances company staff are not generally involved in devising solutions to their own problems, nor do contracting consultants always attempt to develop the skills of client staff or pass on their knowledge and expertise. As a result, lack of client ownership and commitment to the strategy identified is almost inevitable.

THE METHODOLOGICAL APPROACH

The approach presented provides a mechanism which overcomes the deficiencies identified above by actively involving company staff in the improvement process. Our research has shown that by making the management team, and not their consultants, fully responsible for the strategic regeneration of their businesses will significantly increase the chance of success. Only through the full participation of the management team in the strategy development process will ownership and commitment to the strategy identified be assured.

In order to achieve this goal a suitable approach must:

- provide detailed step by step guidance
- support and facilitate the process
- develop and train the Company's management team

After investigation of a number of alternative approaches a decision was made to utilise a combination of a workbook supported by a computer based tool.

BEST PRACTICE

In order to discuss the best practices embedded within the methodology one must start by first defining what is meant by the term "best practice" and establish its relevance to business improvement and strategy development.

Although a number of authors have emphasised the importance of adopting best practice to regenerate business and advocated its adoption as almost a universal panacea, few have attempted to define precisely what it means. In the Government initiative 'Managing in the 90's -The Competitive Response', DTI [6] the Rt. Hon Michael Heseltine states the importance of 'Best Practice' for long term survival.

"The business with the best prospects for long term success seem likely to be those which recognise the need for positive changes: to adapt, to innovate and to plan for continuous improvement and the introduction of best practice into all their activities. Adopting best practice in marketing will help you get closer to your customers. Adopting best practice in design, development and manufacture of improved products will help you exploit the opportunities you identify. Adopting best practice in purchasing will help you make full use of the potential of your suppliers".

A useful starting point to understanding 'best practice', is to clarify what is understood by 'best' and 'practice' individually. An analysis of each of the terms comprising the phrase 'best practice' using the Oxford English Dictionary and Cambridge English Dictionary revealed the following:

Best: applicability within a certain category or in certain circumstances, comparison with all others.

In addition it was reasonably deduced that best does not imply perfection. The underlying notion is one of comparison with all others in a sufficiently homogeneous set to make meaningful comparisons possible. With regard to **all** others, this may prove impractical in practice.

It is also important to note that none of the definitions examined states or even implies that what might be considered to be 'best' cannot be improved upon.

Practice: a physical action or activity of some kind, repeating or pursuing an action.

Clearly, then 'practice' is not theory. It has a physical manifestation. This is not to suggest that the activity or action is unconnected or unsupported by theory, but in so much as it relates to theory, it is applied theory.

The authors define "best practice" as:

An activity or action which is performed to a standard which is better or equal to the standard achieved by other companies in circumstances which are sufficiently similar to make meaningful comparison possible.

In the authors view, the means by which best practice may be acquired is the knowledge acquisition process, Checkland and Scholes [7]. Thus, when attempting to acquire best practice, the management team must first be aware that a particular practice exists.

Once aware, the next step involves the construction of a relevant mindset to enable comparison of the practice in relation to an identified relational group or set.

In this context the management team must develop an ability to evaluate the relative superiority of the best practice in relation to the identified set. This enables the management teams' experience based knowledge to grow and evolve. This leads to purposeful action in relation to their perceived situation (supported by experienced based knowledge), which in turn creates new experiences which further enhance the experienced based knowledge of the team.

This cycle, Figure 1, continues enabling greater understanding and promoting better performance achievements through such learning experiences promoting deliberate, decided, willed action.

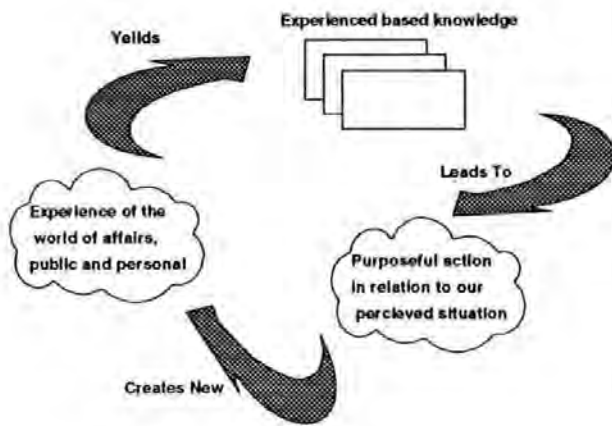


Figure. 1. The experience action cycle

In this context "best practice" can be embedded in the strategy formulation process. The knowledge embedded within the methodology includes: Stakeholder Analysis, Boston Consultancy Grids, Price of Non-competitiveness, Order Qualifying - Order Winning Criteria, resource Impact Matrix etc. These not only enable analyses to be conducted via tried and tested methods, but make the management team aware of the existence, and use of such techniques.

Basis and Rationale for tool development

Declining costs of computer technology, and the advent of well structured, simple to use designs are influencing more small businesses to use computers, Cooley [8]. Based on this notion, computer based tools may therefore provide a cost effective vehicle for initiating best practice programmes within small manufacturing businesses.

The use of the computer for the provision of 'interactive' learning provides the possibility to both optimise and facilitate the accessibility of the learning experience, Gotz [9]. This optimisation is characterised by a number of key attributes:

- 1 A computer assisted learning mechanism may be produced by a team of experts in content, presentation and design.
- 2 The learner may designate the time and place for the learning to take place.
- 3 Advanced mechanisms offer varying paths of instruction depicted by a self assessment of the skill of the learner.

- 4 The learner may request the assistance of help modules to provide support in the learning module.
- 5 Classification of test results may be integrated into the delivery mechanism.
- 6 The learning sequences may be repeated as often as is needed and may take place directly at the workplace when and where a learning need arises.

Based on these attributes and the need to find effective delivery mechanisms affordable by SME's, prototype computer based tools were developed. The approach used to design computer based best practice delivery mechanisms is based on previous work by Clark [10].

Clark points out that there is no theoretical reason for comparing computer and traditionally delivered instruction. There are however, many reasons for comparing instructional designs for creating courseware. As a field, it has finally been accepted that technologies do not mediate learning. Rather, knowledge is mediated by the thought processes engendered by technologies.

Thus, when attempting to use computer based technology as a delivery mechanism to stimulate learning, it is important to focus on the instructional designs that result in the most productive thought processes, which in turn result in the greatest learning. Learning is therefore more directly affected (mediated) by the instructional designs (soft technologies) than it is by the microcomputer (hard technology).

CBT design

Bentley [11] suggests learning is conducted via direct interaction between ourselves and our environment, and that, learners know 'how to learn'. This concept explicitly recognises the need for the creation a computer based environment which enables the recipient to learn in their own 'personalised' way.

The use of a computer based tool for teaching in this case, may be viewed as following two distinct paths. First, the provision of 'tools', [12] Taylor which enable the learner to conduct 'experimental learning', Bentley [11].

For example, a module was designed which provided a tool for the learner, which was based on environmental scanning and Stakeholder

concepts. Providing a 'tool' in this way enforced an approach in which the learner consciously took an holistic view of the relative performance of the key Stockholder's (customers, competitors, suppliers) in the context of the business information supplied.

In addition, support must be provided for this method of learning. Information was supplied in a set of 'tutorial' style modules, 'Quick Tour', which provided the background knowledge and context for the objectives of the tool. This included the provision of information on the origin, rationale for each activity supported by worked examples directly relating to the experimental learning exercise presented in the tool mode.

Information was stored hierarchically and accessible by uncovering further detail when required by the user. Each item of information would have associated items based on the following criteria: possible interest, probable interest, more specific, more generic, Bentley [11].

Furthermore, the identified 'best practice' was partitioned into discrete modules to facilitate the comprehension of its content and provide visible goals to enhance the motivation of the learner.

A decision was taken to only use the CBT to manage the regeneration programme, perform any required analysis and to maintain and update information and for management development and training. Quite deliberately it was felt vital that the role of company staff was to weigh and judge the information presented to them and collectively arrive at some consensus on an appropriate course of action.

The underlying rationale for the development of the methodology and the Tool was to provide a process for strategy development and provide a mechanism for transferring knowledge of best practice to the management teams of small and medium sized manufacturing enterprises.

TESTING WITH SME'S

The methodology was tested in two large companies and the CBT supporting the methodology was tested in four small and medium sized companies. The companies chosen reflected a range of manufacturing situations from the manufacture of one-off, technically complex engineering systems to high volume manufacture of printed circuit boards.

The report of the tests undertaken with SME's considers both the methodology and the tool.

Methodology

All the companies expressed satisfaction with the underlying approach which differentiated the strategy development process into:

Strategic Analysis

- Corporate mission
- Strategic audit
 - Stakeholder analysis
 - Contribution analysis
 - Product portfolio development
- Competitive audit
 - Order qualifying criteria
 - Order winning criteria
 - Price of non-competitiveness

Manufacturing Analysis

- Manufacturing Audit
- Resource impact analysis
- Solution generation

Manufacturing Strategy

- Assemble solution streams
- Challenge solutions
- Develop manufacturing strategy

Action Planning

- Identify resource requirements
- Identify solution contributions
- Agree and prioritise actions

All the companies found the process logical, appreciated the level of detail provided and the explanations in the form of a rationale for each activity. However, it soon became apparent that the management teams in most of the small and medium sized companies were unfamiliar with the underlying analytical tools contained in the methodology. In this respect the provision of 'Toolkits', which provided step by step instructions on the techniques required to complete pre-works, were well received.

Initially some difficulties were experienced by all the companies in obtaining the data required. Though each agreed that the data was essential to the effective operation of their businesses, they had not ensured its provision prior to the testing of the methodology. The lack of data considerably slowed the process in all the companies.

In order to respond to this problem a review was carried to ensure that the data required was kept to the absolute minimum. As a result of this review the methodology was redesigned so that, for example, in Manufacturing Audit, data was only requested with respect to the particular competitive need. That is, only cost data was requested when cost reduction was the objective, time data when delivery leadtime was the objective etc. Similarly, with respect to the Stakeholder Analysis, instead of identifying all Stakeholder's the methodology was adapted to collect information on only the most important Customers, Competitors and Suppliers.

This approach considerably simplified the process and avoided the collection of much unnecessary information. This was achieved without, it appeared, significantly degrading the quality of the analysis and strategy development process.

The Workshops proved successful in identifying and resolving problems and in providing a forum for interaction and team building. In addition, the detailed discussions, allowing the Managing Director to assess, the contributions of the management team, obtain consensus and get ownership and commitment to the solutions generated.

CBT

After some initial difficulties due to the fact that many of the users were unfamiliar with computer applications few problems were encountered. The problems were overcome by redesigning the screens, installing protection to restrict data entry to designated areas of the screen, disabling the second and third (if fitted) mouse buttons.

Having overcome the initial problems the tool was accepted by most of the users. Those users who were more familiar with computer applications running under the Windows environment gained a rapid appreciation of the underlying concepts of the methodology and the functionality of the CBT via the 'Quick Tour' introduction. Those less familiar not surprisingly took longer, however all were able to operate the software competently.

Using the Tool

A feature of the Tool which users found particularly valuable was its ability to perform various analyses automatically. This was found useful in completing the Stakeholder, BCG 1 and

BCG 11 grids and in carrying out the resource impact analysis.

A surprising, but highly welcome, role of the Tool was the support it provided for co-operative working. In this capacity the software, in effect controlled the pace of the process in a manner akin to computer aided co-operative working, Hughes [13]. In addition, the software provided additional support by automatically printing and disseminating Pre-works, Toolkits and Workshop agenda's to identified participants.

In all cases decisions were left to the management team with the computer used to generate and disseminate 'evidence' for consideration by the participants at Workshops.

The design of the Tool allowed it to be used 'off-line', that is when not operating in the strategy development process, for management development and training. This proved invaluable in bringing certain members of the management team up to speed in the various analytical methods associated with strategy development.

CONCLUSIONS

The results of an intensive 16 man year research programme aimed at developing and testing a methodology to guide businesses through the process of formulating coherent strategies has been reported.

The methodology not only to guide companies through strategy formulation, but has been designed to transfer knowledge of best practice. The delivery mechanism utilised, a combination of a workbook and a computer based tool, has been shown to provide management teams with an effective approach, which is particularly suitable for small and medium sized manufacturing companies.

The use and testing of the methodology with a number of such companies has been reported focusing particularly on the application of the methodology and tool.

REFERENCES

- 1 Hughes, D. R. and Maull, R. S., 1990, STRATAGEM - A Methodology for Matching Manufacturing Analysis to Business Requirements, International Conference on Production Management, Warwick, UK.
2. Eyre, B., 1993, 'Innovating for Wealth Creation', Management Today, June, p 5.
3. Maull, R. S. and Bennett, J. P. H. and Hughes, D. R., 1992, MAESTRO: Management Evaluation of Strategic Options, 7th International Conference of Operations Management Association, Manchester, UK, Amsterdam: North Holland, 63-71.
4. Hughes, D. R., Smart, P.A. and White, S., 1994, Benchmarking Manufacturing Performance - The Results of the UK Manufacturing Survey 1993", Operations Strategy and Performance, European Operations Management Association, Ninth International Conference, Cambridge, UK.
5. Ibrahim, A. B. and Goodwin, J. R., 1986, 'Perceived Causes of Success in Small Business', American journal of small business, Fall pp 41-50.
6. DTI, 1990, Managing in the 90's -The Competitive Response.
- 7 Checkland, P., and Scholes, J., (1990), 'Soft Systems Methodology In Action.', Wiley
8. Cooley, P. L., Waltz, D. T., and Waltz, D. B., 1987, 'A Research Agenda for Computers and Small Business', American Journal of Small Business, 12, 3, Winter, pp. 31-42.
9. Gotz, K., 1991, 'Interactive Learning with the Computer', Educational Training and Technology International (ETTI), 28,1, pp. 7-14.
- 10 Clark, R. E., 1986, Research on Student Thought Processes During Computer Based Instruction, Journal of Instructional Development, 8, (3), 2-6
- 11 Bentley, T., 1992, 'Training To Meet The Technology Challenge.', McGraw-Hill Training Series.
- 12 Taylor, R., 1980, 'The Computer in Education: Tutor, Tool and Tutee', New York: Teachers College Press.
- 13 Hughes, D. R., 1994, Guidelines for the Next Generation of Design Tools to Support Multi-disciplinary Team- working, 2nd International Concurrent Engineering and Design Automation Conference, Bournemouth, UK, pp 135 -138

The use of process modelling in benchmarking

S J Childe & P A Smart

School of Computing, University of Plymouth,
Plymouth PL4 8AA, United Kingdom

The increasing interest in benchmarking as a tool for achieving radical improvements in a business' competitive performance has encouraged many companies to attempt a comparison of their performance to that of others. This has been attempted in two main ways. Companies who compare their performance to that of their competitors restrict their potential operating improvements to a position of equality with the competitor, who may by then have moved on. Those companies attempting to look into other industries to gain real originality may fail if they do not focus on activities which are directly comparable. This paper looks at the need to identify the correct activities to study and proposes a modelling technique which can help the company to establish a baseline for comparison.

1. WHAT IS BENCHMARKING?

The term "benchmarking" has become the vogue term in the management arena in the nineties. One may suppose its origin lies in other professions such as carpenters or drapers who may have made marks upon their benches to allow standard measurements to be taken. The term has also been defined [Chambers 1988] with reference to the discipline of surveying:

"A surveyors mark indicating a point of reference anything taken or used as a point of reference or comparison, a standard, criterion etc"

A useful definition of benchmarking is as the development and use of reference points or standards against which business performance can be judged.

Bob Camp [1989] describes Benchmarking as "the search for those best practices that will lead to superior performance for a company". His text presents a structured approach for searching for those industry best practices and implementing them into a business environment. A number of philosophical steps which are fundamental to the success of benchmarking are identified:

- * Know your operation
- * Know the industry leaders or competitors

- * Incorporate the best
- * Gain superiority

The ability to gain superiority is dependent upon a detailed understanding of the company's own operations and those of others and the ability to incorporate these to develop performance improvements. It is the authors' opinion that many companies which attempt benchmarking go ahead without the detailed knowledge of their own business which is vital to allow the appreciation and assimilation of the best practice exemplified in other companies.

The process of searching for industry best practices should be seen as a learning activity. Companies learn how they operate, they try to learn how their competitors operate, and aim to learn how industry leaders operate, so that they can apply the knowledge gained to their own businesses. Paradoxically, while benchmarking tends to focus upon learning about others, its success may depend upon learning about the company's own processes to set the agenda for the study and to allow the findings to be used.

External comparison depends upon being able to identify the leaders whose practice is the best. This knowledge may not be available within the company and assistance from external knowledge sources may be required. These sources might be consultants, academics or institutions such as benchmarking groups. As the company performs successive benchmarking exercises, this knowledge base can be expected to increase.

"Best practice" may be hard to find. It would be impossible for a company to conduct an exhaustive search of all the potential best practices across all industry sectors. This means that it is likely that a company would not identify the overall best exemplar. The company must conduct their search for best practice given the limitations imposed on them by their available knowledge base, that is to say, they may only search for those industry best practices which they feel to be most appropriate given their knowledge of the industrial sector. This base should grow and provide more pertinent pointers to the industry best as the number of iterations of the benchmarking process increases.

If companies are to emulate the practices of other firms it would appear that the best possible result would be to match their performance, since it appears to be impossible to surpass the standard upon which the exercise is based. However, this would be to overlook the benefits from formulating a hybrid "better" process comprising the best ideas from the studies conducted. To excel in this area the company must use the knowledge gained as a potential source for creativity. Without this sort of innovative process a company can never aspire to be a leader itself. Benchmarking must not be seen as a strategy to imitate other companies but as a mission to use the experience of others as a source for novel ideas. This approach is discussed by Smith et al [1992].

2. IDENTIFICATION OF ACTIVITIES FOR BENCHMARKING

The concepts of best practice and benchmarking sometimes appear to trivialise the problem by addressing a level of performance which can be described as "best" or as "best in class". This overlooks the simple question of how to measure performance. The company which performs a particular activity in the best way to suit its own particular business strategies - possibly quite well known as the most successful company in the business - may not address the same aims as the company who wishes to learn from them.

Simple performance measures can be used to illustrate this point. Manufacturing companies often base their strategies upon a particular balance between the measures of cost, quality, functionality, delivery lead time and delivery reliability etc. If a company has a strategy of operating a particular activity at the lowest cost, it may make compromises to the service it offers to its customers, for example. A company in the upper end of the market might compete primarily upon the basis of service quality. For these two companies, the best way of achieving the activity may mean two different things. They may be incompatible for benchmarking purposes.

The activities which are to be compared must therefore be identified not only on the similarity of the task but also on the basis of the competitive business objectives which govern the task. If they do not agree, there may be scope for learning from an alternative approach, as long as the differences are understood.

Similarly, the business environment must be considered when selecting a benchmarking partner. For example, if a company was benchmarking its procurement activities, it would not necessarily be wise for a company in the business of one of a kind production to benchmark itself against a high volume low variety producer, because the competitive requirements of one company would not be satisfied by the activities found to be good at addressing the requirements of the other. The way a company needs to manage its supply arrangements in a high volume business where "clout" is available is likely to be quite different to the arrangements which would enable the purchase of small numbers of widely different items from a wide range of suppliers. However, we may also argue that to achieve radical performance gains, looking at activities in radically different companies might be a valuable exercise. A good example of this is provided by the well known case study illustrating the benchmarking exercise between Xerox and L L Bean [Camp 1989].

Following the implementation of a planning system in the inventory control area, Xerox identified the picking operation as the greatest bottleneck.

The benchmarking effort resulted in L L Bean - an outdoor sporting goods retailer and mail order house - being used as the main benchmarking partner. Whilst the two companies would appear to be dissimilar, the processes were comparable:

"... L L Bean products may bear no resemblance to Xerox parts and supplies. To the distribution professional, however, the analogy was striking: both companies had to develop warehousing and distribution systems to handle products diverse in size, shape and weight" [Camp 1989]

If it is accepted that a similar activity with similar competitive priorities can be found in a potential benchmarking partner, one may assume that there would then be a reasonable foundation upon which to copy the superior performing company's practices. This reassurance would increase as a function of the degree of consistency in the nature of the task - the inputs and outputs agreeing - and the degree of consistency in the performance measures. Unfortunately the simple act of copying from another company may not be a simple as it seems.

It was pointed out by Juran in his address to the winners of the Malcolm Baldrige National Quality Award in 1989

"to learn from experience requires a transfer of knowledge. Such a transfer of know-how should not be done by mimicking what the winners did. Mimicking is risky because of the differences in respective cultures. A reliable transfer of know-how requires thinking through what are the lessons learned it is the universals which are transferable from one culture to another."

Hayes and Pisano observe [1994] "Two companies may adopt similar strategies and production processes, but one can end up being far more successful". A strategy shift is needed to that of "learning" from the experience of others rather than copying. This shift is from imitating other companies to using them as a source for novel ideas [Smith et al 1992].

The use of benchmarking as a source for novel ideas provides the basis for the potential creation of innovative activities. Viewing benchmarking in this fashion also provides the potential to surpass the industry best. Copying implies only matching the performance of a particular activity, whereas the creation of hybrid solutions based on the industry best has the potential to itself be the best, since it creates something original and new.

Benchmarking, viewed as the basis for corporate learning, therefore requires a technique to allow:

- * the identification of the key business activities;
- * detailed activity definition to allow comparison with other companies;
- * the characterisation of the relevant performance measures.

This should allow benchmarking to operate across industry boundaries between companies who do not compete with each other.

3. DESCRIPTION OF BUSINESS ACTIVITIES

In order to ensure that the benchmarking exercise compares like with like, and to ensure the performance measures and other conditions are similar, a means for describing activities and business processes is required which allows the appropriate level of detail to be drawn out, and which allows the performance criteria to be compared. This can be achieved by the use of a hierarchical method which allows activities to be decomposed into various levels of detail, whilst showing the business context which provides some information about performance requirements. Some light is shed on this problem by the research work currently being undertaken in the field of Business Process Re-engineering. Companies are beginning to explore the questions of "how can I identify processes in my business?" and "what is a business process?"

According to Davenport and Short [1990], a business process is "the logical organisation of people, materials, energy, equipment and procedures into work activities designed to produce a specified end result". Davenport and Short also state that processes have two important characteristics. Firstly, they have customers and secondly, they cross organisational boundaries and are generally independent of formal organisational structure.

Similarly, Hickman [1993] defines a business process as "a logical series of dependent activities which use the resources of the organisation to create, or result in, an observable or

measurable outcome, such as a product or service". The authors would add that a business process must be initiated by and must provide results to a customer, who may be internal or external to the company.

A useful structure established by the CIM-OSA standards committee [1989] subdivides processes into three main areas: Manage, Operate and Support. The CIM-OSA framework regards *manage processes* as those which are concerned with strategy and direction setting as well as with business planning and control. *Operate processes* are viewed as those which are directly related to satisfying the requirements of the external customer, for example the logistics supply chain from order to delivery. *Support processes* typically act in support of the Manage and Operate processes. They include the financial, personnel, facilities management and Information Systems provision (IS) activities. These definitions serve as a framework which the company may use to focus its benchmarking efforts. Further focus comes from the identification of the processes within these groupings.

4. DEFINITION OF BUSINESS PROCESSES

In the authors' view a business process operates in a manner analogous to the operation of an industrial or chemical process in as much as it comprises "a series of continuous actions or operations ..." [Hawkins 1984] which are performed upon a commodity. It may also be regarded as a conduit along which a commodity flows. In this context, a commodity might be conceptual or material. Such commodities pass along their respective process conduits and are transformed, at different stages in their progress, as various operations are performed upon them. An activity for benchmarking can therefore be defined by the process of which it is a part.

4.1 Manage processes

Direction Setting

This process includes all high level strategic planning activities. It acts as an overall managing activity which takes ideas about direction based upon business and environmental information, including customer feedback, and transforms these into a set of strategies, operational goals and performance measures.

4.2 Operate processes

Order Flow (Products)

The Order Flow process takes the customer order and transforms it into a finished product. The commodity which flows through this process is the customer's specific product requirement. This initially takes the form of an order and is transformed into a product which embodies the customer's requirement. As the order flows in one direction, money flows in the other; thus the process ends only when the product is accepted and paid for by the customer.

Activities within this category may include raw material purchasing, product assembly, the production of the product, obtaining orders, delivery and installation of the product, invoicing and money receipt.

Service

This process takes the customer's requirement for a service and satisfies it by providing that service. For example the requirement could be the need to keep machines operating reliably, transformed by the service into an assurance of trouble-free performance. Activities include the management of customer enquiries and the provision and management of the necessary technical support to satisfy the customer.

4.3 Support processes

There are a considerable number of activities which are required to support the key business processes. These relate the company to its business environment, which can be thought of as a series of markets within which the company operates. These have been identified by Fine and Hax [1984] as capital markets, labour markets, technology markets, factor markets and product markets. Each of these markets is addressed by the company through a business process.

Capital markets

The process attracts investment into the firm and provides benefits (typically shareholder dividends) thus maintaining the company's position in the capital market.

Labour markets

The process of recruiting, training, remunerating, motivating, appraising and retiring employees. By processing employees, the company maintains its human resources and its position with respect to the labour market.

Technology markets

The assessment and development of available technology, and the selection, installation, maintenance and disposal of plant and equipment.

Factor markets

The establishment and development of relationships with suppliers, supplier development and liaison, and the termination of relationships with suppliers no longer required. This process may also be concerned with the make-or-buy decision.

Product markets (and the market for services)

The company retains its competitive position in the market place by a process which maintains the awareness of its potential customers. This "marketing" activity may be seen as part of the operating process since it involves obtaining orders and providing service, and since the company's position in the product marketplace must ultimately depend on the way in which orders are satisfied.

5. PROCESS MODELLING

Having identified the process which is to be considered for benchmarking, the process must be presented in a way which allows communication, understanding and analysis. Various types of process modelling tools fulfil these requirements. One of the most popular tools is IDEF₀.

IDEF₀ comprises:

- * A set of methods that assist in understanding a complex subject;
- * A graphical language for communicating that understanding;
- * A set of management and human-factor considerations for guiding and controlling the use of the methodology.

IDEF₀ uses top-down decomposition to break-up complex topics into small pieces which can be more readily understood. The diagrams are related in a precise manner to form a coherent model of the subject.

The whole system and the relationship of any part to the whole remains visible. This means that the environment in which an activity takes place is shown in terms of the effects of other activities and externalities which impinge upon the activity in question.

The graphical language of IDEF₀ uses boxes and arrows coupled together in a simple syntax as shown in Figure 1.

Each box on a diagram represents an activity. The arrows that connect to a box represent real objects or information needed or produced by the activity. The side of the box at which an arrow enters or leaves shows the arrow's role as an input, a control or an output. Incoming arrows (which are shown on the left and top of the box) show the data needed to perform the activity. Outgoing arrows (right of the box) show the data created when the activity is performed. An input is converted by the activity into the output. A control describes the conditions or circumstances that govern the transformation. The bottom of the box is reserved to indicate the mechanisms or means (person, device, computer model etc.) used to carry out the activity.

IDEF₀ is a method very well suited to the specification outlined earlier. Its specific strengths lie in that it is a tool designed for modelling processes and in our view it is relatively easy to use. It uses a structured set of guidelines based around hierarchical decomposition, with excellent guidance on abstraction at higher levels. If used well this ensures a good basis for communication and a systems perspective.

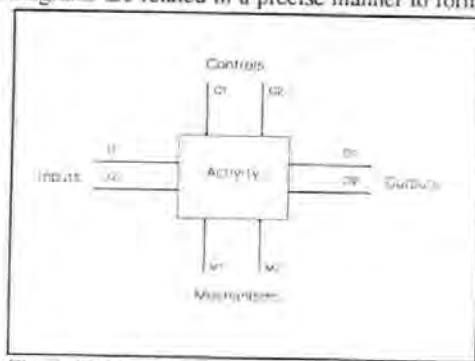


Fig. 1 IDEF₀ Syntax

6. DESIGN OF NEW PROCESSES

Once a model of a process has been created, a part of the process can be selected for redesign by benchmarking. The process model shows how the part must link in to the whole (in terms of the inputs, outputs and constraints) and provides a boundary within which activities can be redesigned. Thus the model provides the means to identify activities which can be replaced by better activities, the ideas for which may come from benchmarking.

Whilst research is continuing into the identification of standard business processes, it is clear that certain activities must be performed by most companies. This was tested in previous work [Childe 1991] in which an attempt was made to divide production management into its constituent tasks, and then to decompose these tasks into lower level elements, and so on as far as possible. For use in benchmarking, the model provides a structure in which the company can determine that a particular business activity is required, and use benchmarking to help to decide what lower level tasks should be used. This analysis can be applied at any level of abstraction, where the higher level always sets the requirement to be fulfilled by the lower level.

For each of the tasks in the model an attempt was made to determine why the task was required for the particular company. These task determinants aid the use of the model as a template to determine which tasks are required in a company under investigation.

Three types of task were recognised.

Core tasks

Some tasks appear to be necessary in every manufacturing company, in which case the benchmarking exercise could only affect the way in which the task was performed. These tasks were regarded as "core tasks". These included for example "Process orders", "Handle goods inward".

The decomposition of a core task could include optional tasks according to the way in which the core task was performed, particularly the decision whether or not to computerise the task. Thus the critical question for a core task is only how it should be done, which is determined by the selection of lower level tasks of which it is constituted.

Optional tasks

In the cases where the task requirement was seen to depend upon the situation, the task was regarded as "optional", since there would clearly be cases in which the task was not required. Examples of these include "Confirm order to customer", "Inspect goods". Where they could be determined, the particular reasons for optional tasks being necessary were recorded.

Dependent tasks

These were tasks which were found in the decomposition of optional tasks, but which were not themselves optional. These were necessary in any instance in which the parent task was required, thus depending upon the appearance or non-appearance of an optional task. For example, "Report capacity requirements" is an optional task whose decomposition must

always include "Aggregate product profiles" and "Identify work for specific time buckets". These tasks are therefore compulsory in the case of the parent task being required.

The design of a new system, or the amendment of an existing system, depends upon being able to take important decisions about the way tasks should be carried out. Inevitably this means identifying the most appropriate set of lower level tasks to fulfil the task, and then for each of the tasks to select the means of carrying out the task, such as by human or mechanical/electronic means.

Work is proceeding on the development of generic process models which can reduce the time taken to produce the initial model for benchmarking. These models will also allow easier comparison between companies.

7. CONCLUSION

Effective benchmarking depends upon being able to identify correctly suitable activities in example companies, through analysis of the activity itself, its performance objectives and measures, and the competitive situation of the business. Good understanding of the role of any activity to the competitiveness of the business can be provided by an approach which sees the activity in the context of a business process. A modelling technique such as IDEF₀ can be utilised to provide an understanding of the activities in question and to provide the basis for redesigning the process. Decomposition of the process into its constituent activities, tasks and sub-tasks provides the means to decide at what level the benchmarking activities should be conducted, thus identifying the correct unit of analysis.

REFERENCES

- CAMP R, 1989, *Benchmarking - The search for industry best practices that lead to superior performance*, American Society for Quality Control
- CHAMBERS, 1988, *Chambers English Dictionary*, W & R Chambers Ltd and Cambridge University Press
- CHILDE S J, 1991, *The design and implementation of manufacturing infrastructures*, PhD Thesis, Polytechnic South West
- CIM-OSA Standards Committee, 1989, *CIM-OSA Reference Architecture*, AMICE ESPRIT
- DAVENPORT T H & SHORT J E, 1990, *The new industrial engineering: information technology and business process redesign*, *Sloan Management Review*, Summer
- FINE C H & HAX A C, 1984, *Designing a manufacturing strategy*, WP # 1593-84, Sloan School of Management, MIT, USA
- HAWKINS J M H, 1984, (Compiler), *Oxford Paperback Dictionary*, Oxford University Press

HAYES R H & PISANO G P, 1994, *Beyond world-class: the new manufacturing strategy*, *Harvard Business Review*, Jan-Feb

HICKMAN L J, 1993, *Technology and Business Process Re-engineering: Identifying Opportunities for Competitive Advantage*, *British Computer Society CASE Seminar on Business Process Engineering*, London, 29 June

RALSTON D, 1992, *Measure for measure*, *Proc. 27th Annual Conference of British Production and Inventory Control Society (BPICS)*, November, pp225-237

SMITH S, WHITTLE S, TRANFIELD D & FOSTER M, 1992, *Implementing Total Quality - the downside of best practice*, in Hollier R H, Boaden R J and New S J (Eds.) *International Operations: Crossing Borders in Manufacturing and Service*, Elsevier

Current issues in business process re-engineering

Current issues in
business process
re-engineering

R.S. Maull, A.M. Weaver, S.J. Childe, P.A. Smart and J. Bennett
University of Plymouth, UK

37

Introduction

Over the past five years business process re-engineering (BPR) has emerged as a popular approach used by organizations seeking improvements in their business performance. Interest in BPR was sparked by Hammer who wrote a seminal article entitled "Re-engineering work: don't automate, obliterate"[1]. While there have been numerous BPR projects undertaken since then, relatively little empirical research has been undertaken in this field. Surveys such as those conducted by the Highams Group[2] and Business Intelligence[3], for example, focus only on the levels of interest in, the motivation for and the benefits to be gained from BPR. They provide no guidance regarding the key factors which need to be considered in any BPR programme.

Hall *et al.*[4] have attempted to remedy this deficiency by proposing three critical determinants of successful BPR projects. These are:

- (1) Breadth – whether the project is set up to improve performance across the whole business unit.
- (2) Depth – the change to six fundamental organizational elements, namely organizational structure, roles and responsibilities, measurements and incentives, information technology, shared values and skills.
- (3) Leadership – the extent of top management commitment.

The work reported here is similar to that undertaken by Hall *et al.* insofar as it sought to identify the key issues underpinning a BPR programme. However, our work differs from their earlier research in two major ways. First, in their sample of 20 projects Hall and his colleagues have concentrated on large companies, mainly located in the USA. Our results have been achieved through research undertaken in a range of companies, both large and small, located solely within the UK. Second, the primary focus of the Hall article rests with the re-engineering or change issues in BPR. Our work recognized the importance of re-engineering but was also concerned with investigating the nature of the business process itself.

This article reports the findings from two pieces of research, EPSRC (DIP) research grant GR/J95010 and EPSRC (IMI) research grant GR/K67328. We would like to thank all the companies visited for their help in this research.

International Journal of Operations
& Production Management, Vol. 15
No. 11, 1995, pp. 37-52. © MCB
University Press, 0144-3577

In-depth study of four companies

The research team has been actively involved in BPR studies for a number of years and has recently undertaken four in-depth BPR studies using the action research approach. There is strong support for the use of action research in the field of production and operations management, for example by Warmington[5], Platts[6], Meredith[7] and Susman and Evered[8]. Outline descriptions of each project will now be presented.

Company A (capital goods manufacturer)

Company A is a manufacturing subsidiary of a larger multi-national organization. It has less than 500 employees on the site where the process redesign project was undertaken. The company had a traditional functional culture with a large number of middle managers. The market in which the company sells its products has dramatically changed and the company has rapidly been losing its market share. The products are made-to-order and have long lead times.

Members of the Plymouth research team were involved in a six-month project to redesign the process of fulfilling spares orders. The managing director sought to achieve an 80 per cent reduction in non-urgent spares lead time quoted to customers. However, the lack of power to change areas outside the control of the production director hindered the redesign and ultimately limited the scale of improvement the company could have obtained. As a result, the redesign effort focused on detailed activities, all of which were under the control of the production director. A number of models of the redesigned process were created on paper using a large flowchart that extended around the room in which the team held its meetings.

Company B (small manufacturer)

Company B is a functionally organized manufacturing subsidiary of a large multi-national organization and employs just under 200 staff. At the time of the research team's intervention, its products were predominantly made-to-stock and produced in large batches. Furthermore, it was seeking to reduce its order fulfilment lead times and increase its customer base by selling direct to retailers as opposed to selling products mainly to wholesalers.

The focus of the project was the order fulfilment process. The managing director of the company initiated the project to reduce the lead time for an order by 50 per cent, however he stressed the lack of resources to undertake any extensive investment. The redesign team was composed of the production and logistics director, a representative from the university research team and representatives from other functional areas which were part of the process. The project lasted three months and the composition of the team remained constant throughout this period.

The IDEF₀ modelling technique was used to represent and analyse the existing process and to create the redesigned process.

Company C (large service company)

Company C is a large service sector organization and employs over 20,000 staff throughout the UK. Both the UK recession in the early 1990s and major changes to customer requirements were forcing the company to reduce costs, to offer new products and services and to focus on its core business. In response to these pressures the company has undertaken a company-wide BPR activity that began in 1993. This activity is ongoing, with an overall budget in excess of £20m, and involves over 50 staff. Various members of the research team have acted in a support role to this project for over two years.

The redesign of Company C's business processes was undertaken by a series of full-time teams under the guidance of process owners who were senior managers of the functional units to be affected by the change. Each redesign team was composed of key personnel from within those functions which had extensive knowledge of the business process in question. The redesign teams were responsible both for analysing and redesigning the business processes.

The original objective of the project was to investigate all the business processes in turn and incrementally improve them by removing non value-adding activities. It was later decided to adopt a more radical approach to redesigning business processes and to aim for significant lead time and cost reductions. More recently, the focus of Company C's BPR activities has changed again and is now concerned with improving service through the redeployment of resources.

Company D (large manufacturer)

For the last 18 months, the research team has been undertaking a BPR project in Company D, a manufacturing subsidiary of a large multi-national organization. The project is ongoing. The company designs and manufactures complex electro-mechanical products on a make-to-order basis and employs over 1,000 staff. Recent international and national political events have significantly influenced the markets in which the company competes. The board of the company is under pressure from the main board of the parent organization to reduce costs while improving overall performance. The redesign project was undertaken in the manufacturing part of the company under the direction of the manufacturing director. The project addressed the fulfil order process.

The redesign team comprises senior staff from different functional areas involved in the process and members of a manufacturing systems group within the organization whose role is to facilitate change. The composition of the redesign team remained constant throughout the analysis and redesign stages although additional personnel were required to facilitate the implementation stage. The redesign team was not empowered to make any changes. Its brief was only to make recommendations to be presented to the process owner (manufacturing director) and his management team.

The company was not aiming for a radical improvement in performance. A set of performance requirements was established which addressed the areas of

delivery, quality and cost. The company claimed to be willing to listen to recommendations for radical change, but since the project was strictly confined to the manufacturing area (notably excluding product design and engineering) the project inevitably assumed a more incremental character.

Interviews with leading practitioners

In addition to these in-depth case studies, the Plymouth BPR team undertook a survey of leading commercial conferences in order to identify companies presenting case experiences of BPR. Four organizations which had undertaken successful BPR projects were selected as exemplars and asked to share their experiences. These were:

- (1) IBM;
- (2) Rank Xerox;
- (3) Lucas Engineering and Systems;
- (4) Coopers & Lybrand (BPR consultancy team).

Unstructured interviews were employed in each organization in order to elicit a rich picture of the history of their BPR projects.

Initial explanatory framework

Analysis of the accumulated experiences of the eight companies so far described showed that, despite the variations in size (from multinationals to SMEs), complexity (make-to-stock to engineer-to-order) and sectors, a set of fundamental issues was emerging which each company was having to address at some point in the life cycle of its BPR project. These issues were grouped together under five main headings, namely scope of change, performance measures, information technology, human factors and business process architecture. Each issue will now briefly be described.

- *Scope of change* – the level of change which the company is seeking to achieve. In both the exemplar and case study companies, different views of the scope of change were uncovered. Each company had its own perspective on the level of change it was aiming for. For example, Companies A, B and D took an incremental approach to change, reflecting the internal scope of the change required. Company C originally took an incremental view and later realized that to make competitive gains it needed to take a much more radical look at the process objectives.

In the exemplar companies, IBM has identified three levels of BPR: continuous improvement, process re-engineering and transformation. Lucas takes a pragmatic view of change within the context of BPR. It defines BPR as an act of fundamental redesign whereby every activity within the process is oriented to satisfy customer needs. Coopers & Lybrand approaches BPR from the radical perspective. Its methodology

looks for “break points” or opportunities for achieving dramatic increases in competitive advantage.

- *Performance measures* – the definition of the operating metrics of the process and the integration of the metrics into an overall set of company performance measures. Through its concentration on the customer supply chain, Xerox provides an excellent example of the way in which performance measures can be used. Xerox proposes a generic process model for manufacturing organizations which has three core processes at the highest level. At the next level these are sub-divided into a further ten processes. From a BPR perspective, however, Xerox is not concerned with anything happening at these levels since they are extremely abstract and liable to change when any company-wide reorganization takes place.

Instead, the company focuses its attention on the third level in the hierarchy where there are 48 sub-processes, each of which has been agreed throughout the company. Activity-based costing and other performance measures can be applied to each sub-process. A sophisticated computer tool is used to show the input-output chains through the existing management structure, the aim of which is to allow the management of the processes to be independent of the current divisional/country/business/strategic unit configuration.

It was clear from the information obtained from Xerox that the company regards the manner in which the 48 processes are grouped as less important than the need to identify, measure and manage the input-output relationships between them. The measures on each of these relationships are then used to benchmark across countries.

The research revealed that IBM is involved in a similar exercise. The company has a complex business process architecture of ten processes, each of which is broken down into a number of sub-processes. All sub-processes have identified process measures.

- *Information technology* – the role of IT in the BPR project. None of the BPR projects in the companies investigated was driven by IT considerations. However, it was clear that consideration of IT was a major factor. For example, as a service sector organization Company C realized from the outset the key importance of IT and that any improved processes must provide a migration path for their existing “legacy” systems. Company D was in a similar situation, having realized that its existing mainframe applications did not support its process requirements and that substantial IT development would be required. The two smaller companies, A and B, were almost totally unconcerned about the information technology implications of their redesign activities. Of the exemplar companies, both IBM and Lucas recognized the importance of establishing a coherent IT strategy during the initial stages of a BPR project.

- *Human factors* – the involvement of employees in the change programme and the implications of their involvement for the redesigned business processes. This was an important issue for all the exemplar companies, especially in the area of teams. For example, IBM stressed the importance of changing employee behaviour in an effort to change the company's organizational culture. The company's ultimate goal was to integrate the BPR teams into the organization. Of the case study companies, only companies C and D (and they only latterly) have begun to address the issue of changing organizational values.
- *Business process architecture* – the definition of an integrated set of business processes. Xerox, Lucas, IBM and Coopers & Lybrand had all developed extensive business process architectures comprising between ten and 60 processes. Companies C and D had also developed their own process architectures, of which Company C's was the most comprehensive, covering all customer facing products.

Widening the research

The issues listed emerged from an analysis of the BPR experiences of only a limited number of companies. The next task for the research team was to broaden the coverage of the research to include a larger sample of companies in an attempt to confirm our understanding of the key issues within BPR.

The companies researched were again chosen from companies presenting their BPR experiences in commercial conferences or which had appeared in the literature as the subjects of case studies. They were drawn from both the service and the manufacturing sectors and varied in size from the Western Provident Association with 500 employees to the Royal Mail with over 170,000. Additionally, an explicit attempt was made to target firms at different stages in the BPR cycle. For example, Milliken indicated that it has undertaken a series of change programmes for 15 years, while Nuclear Electric and British Alcan were at a much earlier stage of their BPR programmes. The companies visited during this phase are listed in Appendix 1.

The research was conducted through a series of interviews either with an individual or, more commonly, with a team which had overall responsibility for the BPR project within the organization. The BPR team was asked to describe their project in terms of a time line beginning with an explanation of why they began the project and outlining the major stages within the project. If any of the five key issues had not been covered, the company was then asked whether those issues had been considered.

This stage of the research was conducted over a nine month period, in parallel with a wide ranging literature search. The combination of the data gathered during the initial and extended set of interviews, the four in-depth case studies and the literature search provided the research team with a valuable data set for analysis and for consideration of the usefulness of the initial explanatory framework.

Results

By drawing together all the work carried out during the extended phase of the research and with reference to the appropriate literature, more detailed evidence underlining the importance of the five key issues will now be presented. The initial issues proposed were: scope of change, performance measures, information technology, human factors and business process architecture. A sixth issue affecting the way in which BPR programmes are carried out, namely strategy, was also identified during this phase of the research and will be discussed here.

Scope of change

By its very nature, BPR is about making changes to an organization. The types of change being undertaken by companies may be placed on a continuum which has incremental change, epitomized by the Japanese continuous improvement approach, at one extreme and the radical business redesign, or "neutron bomb" approach advocated by Hammer and Champy[9], at the other. Dale[10] and Childe *et al.*[11] are among other authors who have presented similar interpretations of such a continuum.

Our research indicates that many financial services organizations take a conservative view of the extent to which they are able to effect major change and that they tend to look for incremental improvements in such service processes as mortgage delivery and current account opening. Conversely, Oracle clearly takes a radical view and has succeeded in reducing the time taken to fulfil an order from 70 to ten days. Similarly, Western Provident Association is now able to change a customer's insurance details in a matter of minutes where before the same process had taken up to six weeks.

Many of the case studies discussed in the literature describe reductions in cost and process cycle times only where small sub-processes are concerned. It would appear from this that there is a commonly held view that a narrow scope of change helps to minimize risks. In recent literature, however, an increased emphasis has been placed on widening the scope of change in order to improve the success of the BPR programmes. Hall *et al.*[4], Watts[12], Cypress[13], Jeans[14] and Champy[15] all suggest that future BPR programmes should attempt to bring about change on a much broader front.

Our research has shown that those organizations which took a radical view of the scope of change were taking much greater risks with their profitability and even survival. However, having gained substantial benefits in terms of lead time and cost reduction, they appear to have increased the likelihood of their long-term viability.

Performance measures

Another important part of any BPR programme is the definition of relevant

will be in a better position both to assess the success of the BPR project and to monitor and improve continuously the way in which the process is carried out.

The development of an integrated set of performance measures encompassing all the business processes within the organization has been proposed by Guha *et al.*[16], Jones[17], Rummler and Brache[18] and Kaplan and Murdock[19]. Without such a performance measurement regime there exists the potential for optimizing one sub-process while, at the same time, sub-optimizing the overall process. For example, the research indicated that Milliken used to measure order fulfilment time only from order receipt to despatch. They now recognize, however, that the customer is far more interested in the total time it takes to receive their order and Milliken has changed its order fulfilment process measure to reflect this. They now measure the entire process from the time the customer places an order to the time that order arrives at the customer's premises. In addition, far more attention is being devoted to shipping time than to in-house processing time because a considerable proportion of Milliken's products are shipped by sea.

Information technology

IT has a key role to play in BPR programmes. Davenport and Short[20], Grover *et al.*[21] and Dennis *et al.*[22] have all approached BPR from an IT perspective. Earl[23] suggests that the IT industry and, in particular, IT management consultants, have played a significant role in promoting the technological side of BPR. However, only one of the companies we investigated had allowed its BPR efforts to be driven by IT considerations. This was a financial services company where technology is a key enabler.

Evidence was obtained from the companies visited that IT influences BPR programmes in three main areas. These are:

- (1) *IT as enabler*: many of the larger companies visited had invested heavily in information technology to enable their BPR programmes. For example IBM, Xerox, D2D and Oracle had all developed in-house software to model business processes.
- (2) *IT used to underpin business processes*: most of the companies visited took the view that IT underpins their business processes and can enable the redesigned processes to meet performance objectives. Western Provident Association has moved from an extensive paper-based system to one based around document image processing and fourth generation languages (4GL). They are currently investing heavily in an object-oriented information system while National and Provincial (N&P) already makes extensive use of such software to support its processes. Cole *et al.*[24], Housel *et al.*[25] and Short and Venkatraman[26] describe successful applications of IT underpinning the business processes in Milacron, Pacific Bell and Baxter's Healthcare respectively.
- (3) *IT as a constraint*: the view was expressed during a number of visits that so-called "legacy" IT systems were constraining the redesign activities.

Most of the financial services companies visited faced extensive problems with their legacy systems which, from a historical perspective, have been designed to support products. Such systems require customer details to be replicated across each database associated with a product (credit cards, mortgages, current accounts and insurance, for example). To re-engineer the architecture of these systems in line with a process focus would be a huge task, and many of these firms expressed an unwillingness even to consider attempting it.

Human factors

The research visits highlighted the overwhelming importance of people in any BPR programme. As one Rover manager put it: "95 per cent of BPR is about the human factor".

The involvement of people in any change programme is usually brought about by the formation of cross-functional teams which are composed of staff drawn from throughout the organization. The redesigned business processes will almost certainly require staff to undergo role and activity changes[27].

Involvement in the change programme

The view was often expressed to the Plymouth research team that BPR projects have gained a reputation for causing large reductions in the workforce and such projects are often treated with suspicion as a result. In many organizations it was recognized that, for an employee to belong to a project team would often lead to the removal of that person's previous job role. As a consequence, many firms have found it difficult to encourage membership of BPR teams.

Nevertheless, many of the companies visited had expended considerable resources on activities aimed at establishing a culture which was open to change before undertaking the BPR programme. Rover stated, for example, that their quality improvement culture was the bedrock of their BPR efforts and indicated that a major BPR project was one of the outcomes of having spent seven years working on the quality "theme". For its part, N&P has spent six years changing organizational values and "mindset"[28] and is now concentrating on building a set of core competences. Milliken has a 20-year history of change projects aimed at gaining organizational commitments and ICL has invested the last ten years in building a quality-oriented culture. All of these major initiatives have prepared these organizations for change and for adapting to change.

However, there was also considerable evidence of what we view as less enlightened practice. While all the companies visited took a team and participatory view, there was often little evidence of anything other than a short term perspective with a number of companies having little or no concept of culture change and few (other than Rover, Milliken, Western Provident Association and N&P) seeing it as part of their remit. Few were paying serious attention to changing attitudes and values.

There have been many suggestions by various writers regarding the management of human factors within the context of a BPR programme. They include:

- leadership from the top[4];
- education[23];
- communication[19];
- middle management “buy-in”[29];
- clear focus[30];
- empowerment[31].

There has also been a notable shift in emphasis towards human factors by Champy[15] with respect to his earlier book on BPR which was co-authored by Hammer[9].

Implications for future work processes

Many authors have pointed out implications for the role of people within the redesigned processes[16,23,32]. The concept of the “triage”, as applied by Leicester Royal Infirmary to its patient treatment, would appear to be relevant in this context, particularly since it has helped the hospital successfully to re-engineer its arthritis clinic. The “triage” approach was developed after research conducted at the hospital indicated that 80 per cent of arthritis patients typically suffer from a standard variant of the disease. A further 15 per cent suffer complications that are relatively common while the final 5 per cent have substantial complications that require extensive expertise to diagnose and treat.

Prior to the change, a patient would first have seen a consultant, blood tests would then have been made, a urine sample taken and analysed and finally X-rays would have been carried out – each of which would have been undertaken by a separate member of staff. The patient would have had to wait for the results of all these tests and before taking them back to the consultant. The consultant would then have diagnosed and prescribed a course of treatment. The problem was that patients could have been spending three to four hours in the hospital before diagnosis and the number of patients seen at each clinic was quite small. There was substantial pressure to reduce overall waiting lists.

As a result, Leicester Royal Infirmary has created a new process for the typical patient. The patient is first dealt with by an individual staff member who has all the skills needed to take and analyse blood tests, analyse urine samples and then carry out X-rays. The patient then takes all this information to the consultant who now has all the data to hand and can quickly carry out a diagnosis. The end result is that a typical patient now spends less than one hour in the hospital. This leaves the consultant much more time to spend with non-standard cases requiring greater expertise.

One of the financial services companies which participated in the research has adopted a similar approach by automating its insurance underwriting activity so that 80 per cent of standard cases are dealt with by a rule-based IT system. This leaves specialist actuaries free to deal with complex cases requiring specialist underwriting skills.

Business process architecture

While traditional approaches to organizational improvement such as organization and methods (O&M) studies or industrial engineering (IE) may well be systematic, that is, "methodically arranged according to a plan", they are not usually systemic, that is, "of or affecting a whole system"[33] and do not focus on the whole process and the integration of work between functions. In contrast, BPR explicitly acknowledges that many business activities cut across both internal and external organizational boundaries, a view supported by Earl[23], who suggests a research agenda which might extend knowledge about the concept of a business process.

The research revealed that Lucas, IBM, Rank Xerox, Triplex, TSB and N&P had all invested considerable resources in defining a business process architecture for their organizations. This ensured that the whole of the organization could be viewed systemically and that the BPR projects to improve the processes selected for re-engineering could be integrated. Rhodes[34] highlights the importance of integration in his generic business process model of an enterprise. Other authors who have recognized the importance of defining a business process architecture include Meyer[35], Kaplan and Murdock[19], Davenport[36] and Harvey[3].

Such use of a business process architecture to achieve a systemic approach is not always reflected in BPR programmes. For example, Company A focused only on spares orders while Company B focused on the whole of the order fulfilment process.

Strategy

As indicated earlier, the extended research identified a sixth issue which plays a key role in determining how BPR programmes are carried out, namely strategy. Strategy is concerned with the degree of alignment between the BPR project and the overall strategy of the company.

During the initial research, which resulted in the identification of five key issues, alignment between the BPR programme and the overall strategy of the company had been taken for granted. However, data gathered during visits to the wider population of companies revealed that while alignment between the strategy and BPR programme was important, it could not be assumed to exist. Indeed, some companies were having considerable difficulty achieving such alignment. For example, the research uncovered how one company had made four attempts at a BPR programme, using different consultants, and had still not achieved senior management approval. Conversely, companies such as Rover, D2D, Milliken and N&P all have well established strategy making

processes, based around policy deployment (*hoshin kanri*), which ensures alignment of process improvements with strategic need.

Policy deployment typically takes around five critical success factors and decomposes these for each set of activities, group and individual within the organization. Performance measures are established which link appraisals with overall strategic direction. The success of the process is often enhanced by "360° individual performance appraisal", where subordinates report on the degree to which staff have "lived organizational values" throughout the year. This process helps to ensure both the strategic alignment of major projects and a culture where appropriate values can be promulgated throughout the organization.

The issue of alignment between the organization's strategy and the BPR programme is one which should be addressed either before or at the start of a BPR programme. Establishing such alignment forms part of the initial stage of many BPR methodologies, including those described by such authors as Guha *et al.*[16], Kaplan and Murdock[19], Harrison and Pratt[37] and Parnaby[38]. This alignment relates to the other key issues which have already been discussed inasmuch as it may significantly affect the scope of the change being undertaken[39], the performance measures employed[18] and the choice of process to redesign[19].

Companies A and B are good examples of the application of BPR as a non-strategic, local intervention and the improvements, while substantial in themselves, have made no real difference to the overall performance of either company. Other companies identified processes on the "not working requires a quick fix" principle. Processes were mapped, analysed and improved incrementally on a project-by-project basis. Little or no attention was paid to the overall strategic direction of the business and how this would affect the BPR project. Consequently, while improvements were undoubtedly made, very little substantial change to the company's cost base or level of service was achieved.

Discussion and conclusions

The findings from this research have implications both for practitioners and the research community.

Implications for practitioners

This article has discussed six of the main issues associated with successful implementation of BPR. These issues have been distilled from an analysis of 21 company visits and four in-depth BPR case studies. It is interesting to reflect that in an earlier analysis[40], the authors were principally concerned with published methodologies for BPR. In that previous work we had investigated methodologies from a wide range of companies which are listed in Appendix 2, and derived from these a composite methodology which consists of five phases:

- Phase 1: Identify or create corporate, manufacturing and IT strategies.
- Phase 2: Identify key process(es) and performance measures.

- Phase 3: Analyse existing process(es).
- Phase 4: Redesign and implement process(es).
- Phase 5: Monitor and continuously improve new process(es).

After 18 months of further research we now believe that strict adherence to such a step-by-step approach is inappropriate and may be misleading for BPR practitioners. Even though a company may go through each phase assiduously, there remains no guarantee that it will fully consider the six issues we have now identified. Where each issue is concerned, however, conscious choices must be made which will affect the way in which the methodology is implemented. For example, the application of a process architecture acts as a structure for the identification of processes in Phase 2 of the above methodology. It also assists the analysis of these processes and acts as a catalyst in Phase 3. Thus the existence of a process architecture will profoundly affect the way the BPR project is carried out.

Similarly, an organization planning a radical rather than an incremental change programme may focus its attention on Phase 4 (redesign), and not carry out any analysis of existing processes. Some organizations which participated in our research focused their BPR efforts almost exclusively on making incremental changes to product-based processes and omitted any strategic considerations. Others, such as N&P, focused on developing an infrastructure for change based around flexible working.

Implications for researchers

In the authors' view the six issues provide a useful framework by which BPR can be researched. Five of these, namely strategy, the scope of change, performance measures, information technology and human factors are clearly enormous topics in their own right and substantial research is currently underway in each area. However, despite the considerable amount of work published about information technologies for BPR[21,22,36] and scope of change within BPR[1], less has been published regarding other issues within BPR. There is therefore considerable scope for further research in the following areas:

- *Strategy*: given the current interest in capability-led strategy, do processes represent a means of bringing together technological and individual routines[41] in ways which offer competitive advantage? How do we build innovation (and possibly redundancy) rather than mere efficiency into process designs?
- *Human factors*: what makes a good BPR team? How should business processes be managed? What are the implications for organizational design in a business process environment? How do we develop processes for organizational learning?

- *Performance measures*: what are appropriate performance measures for processes? If we move towards activity-based costing what are the cost drivers associated with non value-adding support processes?

The sixth issue, namely that of process architecture for BPR, may be the most important of all and the authors believe that the solution to this problem will be found within the domain of systems theory. Work is beginning to emerge on ways to identify business processes, for example through the UK innovative manufacturing initiative (IMI) research framework[42].

Some work has been undertaken to develop high level generic process models from previous research in the areas of computer integrated manufacturing[43] and enterprise modelling[44]. A set of more detailed generic manufacturing process models[45] is currently being validated. However, development of such models has often focused on the relatively straightforward processes where activities and flows can easily be identified, and work needs to be carried out on processes such as strategy development and personnel management. Evidence from Rover suggests that processes can even be established for organizational learning. Clearly, much basic research is required in these areas. More importantly, such models need to be applied. Here, the work of the soft systems thinkers such as Checkland[46] might offer a substantial insight. Research findings in this area are sparse.

At a more mundane level, there is a substantial debate as to the merits of various process analysis techniques. This is a complex subject covering techniques such as flow charting, which can be used quickly but the results of which are difficult to turn into IT specifications, and CASE tools which are very difficult to use yet produce an excellent basis for software design and development. In all these areas we have found substantial industrial interest and a growing community of researchers. The result in the UK has been the establishment by the government of the IMI and we look forward with interest to its findings.

References

1. Hammer, M., "Re-engineering work: don't automate, obliterate", *Harvard Business Review*, July-August 1990, pp. 104-12.
2. Skinner, C. and Pearson, J.R.W., *Business Process Re-engineering in the UK Financial Services Industry*, Highams Systems Services Group Ltd, UK, 1993.
3. Harvey, D., *Re-engineering: The Critical Success Factors*, Business Intelligence Ltd, UK, 1994.
4. Hall, G., Rosenthal, J. and Wade, J., "How to make reengineering really work", *The McKinsey Quarterly*, No. 2, 1994, pp. 107-28.
5. Warmington, A., "The nature of action research", *The Efficiency of Manufacturing Systems*, NATO ARI Series, Plenum, New York, NY, 1983, pp. 51-60.
6. Platts, K.W., "A process approach to researching manufacturing strategy", *International Journal of Operations & Production Management*, Vol. 13 No. 8, 1993, pp. 4-17.
7. Meredith, J.R., "Theory building through conceptual models", *International Journal of Operations & Production Management*, Vol. 13 No. 5, 1993, pp. 3-11.

There have been many suggestions by various writers regarding the management of human factors within the context of a BPR programme. They include:

- leadership from the top[4];
- education[23];
- communication[19];
- middle management “buy-in”[29];
- clear focus[30];
- empowerment[31].

There has also been a notable shift in emphasis towards human factors by Champy[15] with respect to his earlier book on BPR which was co-authored by Hammer[9].

Implications for future work processes

Many authors have pointed out implications for the role of people within the redesigned processes[16,23,32]. The concept of the “triage”, as applied by Leicester Royal Infirmary to its patient treatment, would appear to be relevant in this context, particularly since it has helped the hospital successfully to re-engineer its arthritis clinic. The “triage” approach was developed after research conducted at the hospital indicated that 80 per cent of arthritis patients typically suffer from a standard variant of the disease. A further 15 per cent suffer complications that are relatively common while the final 5 per cent have substantial complications that require extensive expertise to diagnose and treat.

Prior to the change, a patient would first have seen a consultant, blood tests would then have been made, a urine sample taken and analysed and finally X-rays would have been carried out – each of which would have been undertaken by a separate member of staff. The patient would have had to wait for the results of all these tests and before taking them back to the consultant. The consultant would then have diagnosed and prescribed a course of treatment. The problem was that patients could have been spending three to four hours in the hospital before diagnosis and the number of patients seen at each clinic was quite small. There was substantial pressure to reduce overall waiting lists.

As a result, Leicester Royal Infirmary has created a new process for the typical patient. The patient is first dealt with by an individual staff member who has all the skills needed to take and analyse blood tests, analyse urine samples and then carry out X-rays. The patient then takes all this information to the consultant who now has all the data to hand and can quickly carry out a diagnosis. The end result is that a typical patient now spends less than one hour in the hospital. This leaves the consultant much more time to spend with non-standard cases requiring greater expertise.

processes, based around policy deployment (*hoshin kanri*), which ensures alignment of process improvements with strategic need.

Policy deployment typically takes around five critical success factors and decomposes these for each set of activities, group and individual within the organization. Performance measures are established which link appraisals with overall strategic direction. The success of the process is often enhanced by "360° individual performance appraisal", where subordinates report on the degree to which staff have "lived organizational values" throughout the year. This process helps to ensure both the strategic alignment of major projects and a culture where appropriate values can be promulgated throughout the organization.

The issue of alignment between the organization's strategy and the BPR programme is one which should be addressed either before or at the start of a BPR programme. Establishing such alignment forms part of the initial stage of many BPR methodologies, including those described by such authors as Guha *et al.*[16], Kaplan and Murdock[19], Harrison and Pratt[37] and Parnaby[38]. This alignment relates to the other key issues which have already been discussed inasmuch as it may significantly affect the scope of the change being undertaken[39], the performance measures employed[18] and the choice of process to redesign[19].

Companies A and B are good examples of the application of BPR as a non-strategic, local intervention and the improvements, while substantial in themselves, have made no real difference to the overall performance of either company. Other companies identified processes on the "not working requires a quick fix" principle. Processes were mapped, analysed and improved incrementally on a project-by-project basis. Little or no attention was paid to the overall strategic direction of the business and how this would affect the BPR project. Consequently, while improvements were undoubtedly made, very little substantial change to the company's cost base or level of service was achieved.

Discussion and conclusions

The findings from this research have implications both for practitioners and the research community.

Implications for practitioners

This article has discussed six of the main issues associated with successful implementation of BPR. These issues have been distilled from an analysis of 21 company visits and four in-depth BPR case studies. It is interesting to reflect that in an earlier analysis[40], the authors were principally concerned with published methodologies for BPR. In that previous work we had investigated methodologies from a wide range of companies which are listed in Appendix 2, and derived from these a composite methodology which consists of five phases:

- Phase 1: Identify or create corporate, manufacturing and IT strategies.
- Phase 2: Identify key process(es) and performance measures.

- *Performance measures*: what are appropriate performance measures for processes? If we move towards activity-based costing what are the cost drivers associated with non value-adding support processes?

The sixth issue, namely that of process architecture for BPR, may be the most important of all and the authors believe that the solution to this problem will be found within the domain of systems theory. Work is beginning to emerge on ways to identify business processes, for example through the UK innovative manufacturing initiative (IMI) research framework[42].

Some work has been undertaken to develop high level generic process models from previous research in the areas of computer integrated manufacturing[43] and enterprise modelling[44]. A set of more detailed generic manufacturing process models[45] is currently being validated. However, development of such models has often focused on the relatively straightforward processes where activities and flows can easily be identified, and work needs to be carried out on processes such as strategy development and personnel management. Evidence from Rover suggests that processes can even be established for organizational learning. Clearly, much basic research is required in these areas. More importantly, such models need to be applied. Here, the work of the soft systems thinkers such as Checkland[46] might offer a substantial insight. Research findings in this area are sparse.

At a more mundane level, there is a substantial debate as to the merits of various process analysis techniques. This is a complex subject covering techniques such as flow charting, which can be used quickly but the results of which are difficult to turn into IT specifications, and CASE tools which are very difficult to use yet produce an excellent basis for software design and development. In all these areas we have found substantial industrial interest and a growing community of researchers. The result in the UK has been the establishment by the government of the IMI and we look forward with interest to its findings.

References

1. Hammer, M., "Re-engineering work: don't automate, obliterate", *Harvard Business Review*, July-August 1990, pp. 104-12.
2. Skinner, C. and Pearson, J.R.W., *Business Process Re-engineering in the UK Financial Services Industry*, Highams Systems Services Group Ltd, UK, 1993.
3. Harvey, D., *Re-engineering: The Critical Success Factors*, Business Intelligence Ltd, UK, 1994.
4. Hall, G., Rosenthal, J. and Wade, J., "How to make reengineering really work", *The McKinsey Quarterly*, No. 2, 1994, pp. 107-28.
5. Warmington, A., "The nature of action research", *The Efficiency of Manufacturing Systems*, NATO ARI Series, Plenum, New York, NY, 1983, pp. 51-60.
6. Platts, K.W., "A process approach to researching manufacturing strategy", *International Journal of Operations & Production Management*, Vol. 13 No. 8, 1993, pp. 4-17.
7. Meredith, J.R., "Theory building through conceptual models", *International Journal of Operations & Production Management*, Vol. 13 No. 5, 1993, pp. 3-11.

8. Susman, G.I. and Evered, R.D., "An assessment of the scientific merits of action research", *Administrative Science Quarterly*, Vol. 23, 1978, pp. 582-603.
9. Hammer, M. and Champy, J., *Re-engineering the Corporation: A Manifesto for Business Revolution*, Harper Collins, New York, NY, 1993.
10. Dale, M., "The re-engineering route to business transformation", *Journal of Strategic Change*, J. Wiley, Chichester and New York, 1994.
11. Childe, S.J., Maull, R.S. and Bennett, J.P.H., "Frameworks for understanding business process re-engineering", *International Journal of Operations & Production Management*, Vol. 14 No. 12, 1994, pp. 22-34.
12. Watts, J., Editorial, *Business Change & Re-engineering*, Vol. 1 No. 3, J. Wiley, Chichester and New York, 1993, p. 3.
13. Cypress, H.L., "Reengineering", *OR/MS Today*, February 1994, pp. 18-29.
14. Jeans, M., "Change: the pressures and management's response", *Business Change & Re-engineering*, Vol. 1 No. 3, J. Wiley, Chichester and New York, 1993, pp. 41-7.
15. Champy, J., *Reengineering Management*, Harper Business, New York, NY, 1995
16. Guha, S., Kettinger, W.J. and Teng, J.T.C., "Business process reengineering: building a comprehensive methodology", *Information Systems Management*, Summer 1993, pp. 13-22.
17. Jones, C.R., "Improving your key business processes", *TQM Magazine*, Vol. 6 No. 2, 1994, pp. 25-9.
18. Rummier, G.A. and Brache, A.P., *Improving Performance: How to Manage the White Space in the Organization Chart*, Jossey-Bass, Oxford, 1990.
19. Kaplan, R.B. and Murdock, L., "Rethinking the corporation: core process redesign", *The McKinsey Quarterly*, No. 2, 1991.
20. Davenport, T.H. and Short, J.E., "The new industrial engineering: information technology and business process redesign", *Sloan Management Review*, Summer 1990, pp. 11-27.
21. Grover, V., Teng, J.T.C. and Fiedler, K.D., "Information technology enabled business process redesign", *Omega International Journal of Management Science*, Vol. 21 No. 4, 1993, pp. 433-47.
22. Dennis, A., Daniels, R., Hayes, G., Kelly, G., Lange, D. and Massman, L., "Business process re-engineering with groupware", Working paper, Department of Management, Terry College of Business, University of Georgia, Athens, GA, 1994.
23. Earl, M.J., "The new and the old of business process redesign", *Journal of Strategic Information Systems*, Vol. 3 No. 4, 1994, pp. 5-22.
24. Cole, C.C., Clark, M.L. and Nemec, C., "Reengineering information systems at Cincinnati Milacron", *Planning Review*, May/June 1993, pp. 22-6.
25. Housel, T.J., Morris, C.J. and Westland, C., "Business process reengineering at Pacific Bell", *Planning Review*, May/June 1993, pp. 28-33.
26. Short, J.E. and Venkatraman, N., "Beyond business process redesign: redefining Baxter's business network", *Sloan Management Review*, Fall 1992, pp. 7-21.
27. Hirschhorn, L. and Gilmore, T., "The new boundaries of the boundaryless company", *Harvard Business Review*, May-June 1992, pp. 104-15.
28. O'Brien, D. and Wainwright, J., "Winning as a team of teams – transforming the mindset of the organization at National and Provincial Building Society", *Business Change and Re-engineering*, Vol. 1 No. 3, Winter 1993, pp. 19-25.
29. Hutchinson, J., *Creating the Learning Organization*, ODI Ltd, UK, 1994.
30. Finerty, T., quoted in "Shocking to the core", *Management Today*, August 1993, pp. 18-22.
31. Harrington, H.J., *Business Process Improvement*, McGraw-Hill, New York, NY, 1992.
32. Hammer, M., in interview with Vogl, A.J., appearing as "The age of re-engineering", *Across the Board*, June 1993, pp. 26-33.

33. Hitchins, D.K., *Putting Systems to Work*, J. Wiley, New York, NY, 1992.
34. Rhodes, D., "The business process model of enterprise", *Control*, BPICS, February/March 1994, pp. 31-4.
35. Meyer, C., *Fast Cycle Time*, The Free Press, New York, NY, 1993.
36. Davenport, T.H., *Process Innovation: Re-engineering Work through Information Technology*, Harvard Business School Press, Cambridge, MA, 1993.
37. Harrison, D.B., Pratt, M.D., "A methodology for reengineering businesses", *Planning Review*, March/April 1993, pp. 6-11.
38. Parnaby, J., *Business Process Systems Engineering*, Lucas Industries plc (UK), November 1993.
39. Talwar, R., "Business reengineering – a strategy-driven approach", *Long Range Planning*, Vol. 26 No. 6, 1993, pp. 22-40.
40. Maull, R.S., Weaver, A.M., Childe, S.J. and Bennett, J., "State of the art in business process re-engineering in UK manufacturing companies", *1st European OMA Conference*, Cambridge, UK, 27-29 June 1994.
41. Teece, D.J., Pisano, G. and Shuen, A., "Dynamic capabilities and strategic management", Harvard Business School Working Paper, Cambridge, MA, 1992.
42. Innovative Manufacturing Initiative, "A new way of working", *Report of the Innovative Manufacturing Panel*, SERC, February 1994, ISBN 1 870669 79 7.
43. Jorysz, H.R. and Vernadat, F.B., "CIM-OSA Part 1: total enterprise modelling and function view", *International Journal of Computer Integrated Manufacturing*, Vol. 3 No. 3, 1990, pp. 144-56.
44. Eirich, P., "Enterprise modelling: issues, problems and approaches", Report by special interest group, *International Conference on Enterprise Integration Modelling Technology*, South Carolina, 6-10 June 1992.
45. Weaver, A., Maull, R., Childe, S., Smart, A. and Bennett, J., "The development and application of a generic order fulfilment process model", *International Conference of Computer Integrated Manufacturing*, Singapore, 11-14 July 1995.
46. Checkland, P., *Systems Thinking, Systems Practice*, J. Wiley, New York, NY, 1981.

Appendix 1

British Alcan	Milliken
Oracle	Rover
Royal Mail	Woolwich Building Society
Barclays	Triplex
Western Provident Association (WPA)	National and Provincial (N&P)
Nuclear Electric	Leicester Royal Infirmary
Lloyds Bank	IBM Customer Service Division
D2D (previously ICL Kidsgrove)	IBM Research and Development
Nat West Bank	

Appendix 2

Coopers & Lybrand	BP	Lucas Industries plc	Baxter's Healthcare
Glaxo	BT	Digital Equipment	British Aerospace
Wang	Aetna	TSB	Kodak
James Martin & Co.	Xerox	A T Kearney	Pilkington Optronics
IBM	KPMG Peat Marwick	British Airways	Pagoda Associates

The application of generic process models in Business Process Re-engineering

S J Childe, A M Weaver, R S Maull, P A Smart, J Bennett
 University of Plymouth
 Drake Circus, Plymouth, PL4 8AA, United Kingdom
 Tel +44 1752 232618 e-mail stevec@soc.plym.ac.uk

Abstract

Research work is proceeding on the development of a framework that will help manufacturing businesses identify business processes, process components and links between the processes to form a company-wide view. This paper describes the supporting theory of systems and the structure, development and validation of a model of standard business processes.

Keywords

Business Process Re-engineering; process model; manufacturing; SME; IDEF₀

1 INTRODUCTION

The objective of this paper is to describe the development of generic process models for Business Process Re-engineering (BPR) that will encourage companies and participants carrying out BPR projects to take a business process perspective. It will address specifically the application of BPR within Small and Medium Sized Enterprises.

The authors believe that the issue of how to encourage individuals at all levels within a company to think in terms of business processes is critical to the success of a BPR project. This is pointed out by Rummler and Brache (1990) who have found that;

"When we ask a manager to draw a picture of his or her business (be it an entire company, a business unit or department), we typically get something that looks like the traditional organisation chart."

A number of multi-national companies have successfully used generic process models to intervene and change processes within business units, for example Xerox and Shell. The purpose of these generic process models is to encourage individuals within the business units to think in terms of business processes and to provide a starting point for process redesign. The business process view gives the individuals a holistic view of the activities that are carried out within the business units. The authors believe that the use of generic process models could be applied just as successfully by Small and Medium Sized Manufacturing Enterprises (SMEs) to provide a process framework and intervention tool for BPR projects.

2 SME's

The initial problem is to identify which SMEs may benefit from undertaking a BPR project. SMEs have very different characteristics compared to large organisations especially in the area of innovation (Lefebvre et al 1990, Meredith 1987).

Mount et al (1993) provide a framework to deal with this issue which consists of five typical phases of small business development.

1 Owner Operated The owner manages the business and also performs many of the day-to-day productive activities with a small workforce.

2 Transition to owner-managed The owner's role is changing to a state in which the owner is engaged in managing the business full-time, yet the business is small enough not to require a middle level of management.

3 Owner-managed The owner is engaged full-time in the management activities within the business. Supervisory roles may exist but there are no formal functional boundaries.

4 Transition to emergent functional The company is becoming too big to be managed by the owner. Functional boundaries become defined and hence a middle layer of management is required. The addition of specialist middle managers demands substantially more delegation of decision making. In this case the owner is often obliged to screen the viewpoints of senior functional managers and to arbitrate some consensus on a final course of action.

5 Emergent functional organisation A company in which defined functions and managers and a clear organisation structure exists. Middle management is established and functions have frequently established their own objectives, mission statements etc. There may be a conflict of interest between functions, and political manoeuvring may be widespread.

We believe that companies where such conflicts and complexity are emerging are those who may benefit from BPR programmes. The generic models have therefore been developed with emergent functional organisations in mind.

3 GENERIC PROCESSES

In the majority of documented BPR methodologies, including those developed by Coopers & Lybrand, IBM, British Telecom, Xerox and Lucas, one of the initial activities is to identify the core business processes. In identifying the core processes the participants in the BPR project are defining boundaries within their organisation using a process perspective.

By comparing the sets of core processes produced by companies that have undertaken BPR projects, a hierarchy of common processes that are generic across the companies becomes evident. This suggests that a set of standard processes may evolve in process oriented organisations, in the same way that a roughly standardised set of functional divisions (manufacturing, design, sales and marketing, finance, personnel, etc.) developed.

4 AN ARCHITECTURE OF BUSINESS PROCESSES

A manufacturing company can be represented at the most abstract level as a process which transforms inputs into outputs to satisfy the objectives of the various organisational stakeholders. The organisation can be sub-divided into a number of sub-processes that

interact to meet these overall objectives. An overall structure or architecture allows each process to be considered without losing the context of its purpose within the whole organisation. The process view of an organisation ensures a strong emphasis on how work gets done and is a "revolutionary change of perspective" from the traditional functional based view of an organisation (Davenport 1993).

There are many examples of organisations identifying a hierarchy of business processes. It is one of the initial activities in the majority of documented BPR including those developed by Coopers & Lybrand (Johansson et al 1993), IBM (Kane 1986), British Telecom (Harvey 1994), Xerox and Lucas (Parnaby 1993). The number of business processes identified at the various levels within the hierarchy varies considerably from organisation to organisation. Davenport (1993) gives a number of reasons for this variation:

- Processes within organisations are almost infinitely divisible.
- The identification of processes can be exploratory and iterative.
- An organisation seeking to carry out incremental changes is likely to focus on improvements in sub-divisions of processes whereas for radical changes an organisation should attempt to define processes as broadly as possible.

Examples of process identification by organisations can be found in Davenport (1993) and the Business Intelligence report on BPR (Harvey 1994) and many case studies in journal articles, for example Shapiro et al (1992), Davenport and Short (1990).

Two activity types "primary" and "support" activities are identified by Porter in his "value chain" concept (1985). The "primary activities" are those activities that interface with the external customer and add value to a product either by designing, manufacturing or by selling the product. The "support activities" are those activities that enable the primary activities to function.

"Management" activities represent a third type of process, including activities which do not directly add value to the customer, the direction setting, enabling change or managing performance activities. For example Veasey (1994) refers to "Management, Support and Value Adding" processes; Royal Mail have "External Customer, Support and Management" processes; Lucas have "Development, Delivery Operations and Support" processes; Pagoda (1993) have "Manage, Operate and Support" processes. The CIM-OSA standard (AMICE ESPRIT 1989) also groups processes into "Manage, Operate and Support".

The grouping of the processes under "Manage, Operate and Support" emphasises some of the general characteristics of the processes and the approaches to redesigning the different types of processes may be different. For example, the concept of value-added must be applied differently in the Operate and Manage areas. Paradoxically, the grouping of processes is a functionally based analysis rather than a process analysis and must be seen as less important than the analysis of the processes themselves.

4.1 The "Operate" processes

The "Operate" processes are those processes which directly produce value for customers. Value is added if activities lead directly to the fulfilment of a customer's requirements. The core operational processes identified by Champy (1995) and Meyer (1993) for a business are "customer service", "product development", and "order fulfilment". The "customer service" process transforms knowledge of customer requirements and the market into customer orders. The "product development" process transforms the actual or perceived requirements of a

customer into a design that can be manufactured. The "order fulfilment" process takes the order, manufactures and delivers the product to the customer.

The focus of the work in developing a set of generic processes has been on the "Operate" processes because these are the processes where greatest gains in competitive advantage can be made (Hammer and Champy 1993, Meyer 1993, Johansson et al 1993). Analysis of these processes will also

illuminate the most important support process impediments and do so within the context of meeting customer needs (Meyer 1993)

A recent survey (Harvey 1994) also showed that the most commonly cited processes that organisations were targeting for re-engineering included customer service, logistics and new product development.

From our discussions with companies and our comparison of the lists of core processes developed by a number of organisations including Xerox, IBM and Rover, many companies further divide the "customer service" process into two parts. The two parts are the process of getting an order from a customer and the process of providing support to the customer after the order has been fulfilled. We have called these processes the "Get Order" process and the "Support Product" process.

We have thus identified a set of four "Operate" processes within a manufacturing company. We have named each one with an imperative verb so that the process names are consistent with the IDEF₀ models. The four "Operate" processes are

- Get Order
- Develop Product
- Fulfil Order
- Support Product

4.2 Process definition

There are many different views of what should be included or excluded within the boundaries of each process. Each organisation is likely to have a different view. To describe a consensus view of the "Operate" processes we are developing a precise description using a *root definition* and an IDEF₀ model of each of the processes showing activities and flows in each process and between the four processes. These are intended to provide what Wilson (1984) terms a "Consensus Primary Task Model".

To develop a rigorous definition of each process, a "root definition" of the process was defined. The concept of a "root definition" is part of the Soft Systems Methodology (SSM) described by Checkland (1981). A root definition should be a "concise description of a human activity system which captures a particular view of it" (Checkland 1981). Checkland also developed a mnemonic CATWOE by which the six elements that should be covered in a root definition can be remembered. The six elements paraphrased from Checkland are;

- *Customers* of the process, beneficiaries or victims affected by the processes activities.
- *Actors* or agents who carry out or cause to be carried out the main activities of the process.
- *Transformation*, the means by which defined inputs are transformed into defined outputs.
- *Weltanschauung*, the outlook or framework that makes the root definition meaningful.
- *Ownership*, the agency having a prime concern for the system and the ultimate power to cause the system to cease to exist.
- *Environment*, features of the environment of the process that must be taken as given.

Since the generic process models stem from the same work, the Actors, Weltanschauung and Ownership for each are the same. The Actors in each process are the people and machines within the manufacturing company under consideration. These cannot be defined more precisely, as the model has to preserve its generic nature. The Weltanschauung for each model is the same, that is to say they are all intended to be more helpful than a neutral model which would be acceptable to *all* manufacturing companies, but which in its theoretically wide application would lose all meaning. Rather it is intended to produce a consensus model which will accommodate the Weltanschauung of the majority of manufacturing companies. Ownership can only be expressed as the owner of the manufacturing company. In some specific cases, process owners may be created which provide the owner role for a particular process, but this can not be seen as a general concept until the process architecture is generally accepted, thus, it can not be part of it.

The root definitions that capture the view of the authors with respect to the "Operate" processes of any manufacturing company is as follows;

The "get order" process contains activities performed by humans and machines. Its principal transformations are to transform a product or concept of a product into a customer order, to translate customer requirements into a form meaningful to the other processes and to use market data to identify potential requirements for new products. It includes the flow of information that is required to satisfy a customer by providing information to the customer and to the other "Operate" processes. The process constantly seeks to ensure that customers' requirements are met and that there are sufficient orders to meet the stakeholder requirements.

The "develop product" process contains activities performed by humans and machines. Its principal transformation is from knowledge into the specification of a product that can be produced to meet customer requirements. It includes the flow of information to enable development of the specification of a product that can be manufactured and the development of product concepts that may fulfil future customer requirements. The process constantly seeks to provide specifications for products that will meet the requirements of customers whilst balancing stakeholder requirements.

The "fulfil order" process contains activities performed by humans and machines. Its principal transformations are product orders into products and enquiries into specifications. It includes the flow of both the material and the information that result in the fulfilment of the external customer order or enquiry. The process constantly seeks to fulfil customer requirements whilst balancing stakeholder requirements.

The "support product" process contains activities performed by humans and machines. Its principal transformation is a need for support into a product that continues to meet the requirements of a customer. It includes the flow of the resources and information that are required to meet the customer's support requirements. The process constantly seeks to fulfil the customer's support requirements whilst balancing stakeholder requirements.

In the tradition of Checkland's Soft Systems Methodology, the root definitions are being revised as more knowledge about the processes is gained.

5 DEVELOPMENT AND VALIDATION OF THE PROCESS MODELS

5.1 Modelling technique

The model of the "Operate" processes has been developed using IDEF₀ (CAM-I 1980). IDEF₀ is widely used in the manufacturing sector for modelling processes. IDEF₀ comprises:

- A set of methods that assist in understanding a complex subject;
- A graphical language for communicating that understanding;
- A set of management and human-factor considerations for guiding and controlling the use of the technique.

IDEF₀ uses top-down decomposition to break-up complex topics into small pieces which can be more readily understood and which are set in their proper context with respect to other system elements. An IDEF₀ model is an ordered collection of diagrams, related in a precise manner to form a coherent model of the subject. The number of diagrams in a model is determined by the breadth and depth of analysis required for the purpose of that particular model. At all times the relationship of any part to the rest of the whole remains visible.

In summary IDEF₀ provides the ability to show what is being done within a process, what connects the activities and what constrains activities. It uses a structured set of guidelines based around hierarchical decomposition, with excellent guidance on abstraction at higher levels. If used well this ensures good communication and a systemic perspective.

5.2 Level of analysis

The level of analysis is critical when developing a generic model. For the generic model to be of any use it must contain elements which are at a level of detail that allows meaningful discussion within a particular company. Conversely, too much detail would restrict its application. A very detailed model would become specific to a particular company. Thus an attempt is being made to judge the appropriate level of detail.

Using IDEF₀ as a modelling technique ensures that the context for any part of a process model under analysis in relation to the whole of the process model is always known. Therefore a company can focus on the part of a process model it is particularly interested in and develop a further levels of detail without losing its context within the whole process.

5.3 Information sources

The models have been developed with the involvement of a number of manufacturing companies varying in size from Times 1000 companies to Small and Medium Manufacturing Enterprises (SMEs) with under 500 employees.

The information used to develop the process models has been extracted and assimilated from a number of sources including literature (especially Harrington 1984, CAM-I 1984, Porter 1985), previous work (Childe 1991), generic models described in other modelling methods and individual models of company processes.

The IDEF₀ models of the "Operate" processes will cover all four types of manufacturing companies defined by Wortmann (1990); Make-to-stock, Assemble-to-order, Make-to-order and Engineer-to-order.

5.4 IDEF₀ standard process models

The "Operate" processes are represented in a single IDEF₀ model that shows the interactions between each of the processes and external customers, suppliers and other parts of the

organisation that are outside the boundaries of the model. IDEF₀ has allowed us to develop a model of each process separately and then combine the IDEF₀ models into an integrated model of the "Operate" processes. The complete model includes a set of IDEF₀ diagrams and a glossary of terms.

5.5 Validation

The validation of the process models is currently being carried out. Validation methods include criticism and comment by academic colleagues and industrial practitioners experienced in BPR and manufacturing management and a comparison by third parties to their own process models.

6 APPLICATION

In the introduction the critical issue of getting employees to think in terms of business processes was identified. The generic process models are intended to be used as an intervention tool to encourage the participants of a BPR project within a manufacturing company to take a business process perspective. The participants in a BPR project would generally be individuals from the functions who currently perform activities within the process, guided by objectives set by senior management.

In the initial stages of the BPR project, following the identification of a core process to be redesigned, the participants would be presented with the generic process model and glossary of terms and asked to compare the generic process model against the activities within the company. These activities would be carried out under the guidance of an internal or external facilitator.

In carrying out a comparison the model encourages the participants to:

- Take a business process perspective as the generic model provides an existing process framework.
- Develop a consensus view of their own company's process by debating the differences between the generic model and each participants perceived view of the company's process.
- Identify and change the generic model to represent their company's process.
- Identify immediate changes that could be made to the company's process as differences between the model and reality are found.
- Consider the systemic relationship of all parts of the process as model provides a structured medium where inconsistencies in the changed model can be identified easily.

In comparison with current BPR approaches where the participants are encouraged to develop a process model of the existing business process, the use of generic models reduce the danger of participants reverting to tradition functional thinking by providing a process focused framework. It also provides greater momentum to the project than a "blank sheet of paper" and the generic process model is non-political having being produced externally. The non-political nature of the generic process model should enable participants to more freely criticise the model and in doing so generate debate and understanding amongst the group.

7 CONCLUSION

This paper has described the development of a set of generic process models for business process re-engineering in small and medium sized manufacturing companies. Initial validation of the models has supported the view that generic models would be useful in the re-engineering of SME's and the models have raised considerable interest. Further development and validation of the models is proceeding.

Acknowledgements

The research work described in this paper has been jointly funded by the Engineering and Physical Science Research Council under a grant (GR/J/95010) entitled "Specification of a Business Process Re-engineering methodology for Small and Medium Sized Manufacturing Enterprises" and British Aerospace (Systems and Engineering) Ltd.

REFERENCES

- AMICE ESPRIT (1989) : CIM-OSA Reference Architecture
 CAM-I (1980), *Architect's Manual ICAM Definition Method "IDEF-0"*, Arlington, Texas
 CAM-I (1984), *A study program for defining a computer integrated manufacturing (CIM) generic concept for electronic products*, Arlington, Texas
 Champy J (1995), *Re-engineering Management*, HarperBusiness, NY
 Checkland P (1981), *Systems Thinking*, Systems Practice, J Wiley & Sons
 Childe S J (1991), *The design and implementation of manufacturing infrastructures*, PhD Thesis, Polytechnic South West, UK
 Culverhouse P F, 1993, Four design routes in electronics engineering product development, *Journal of Design and Manufacturing*, Vol 3
 Davenport T H and Short J E (1990), The new industrial engineering: information technology and Business Process Redesign, *Sloan Management Review*, Summer
 Davenport T H (1993), *Process Innovation*, Harvard Business School Press
 Hammer M, Champy J (1993), *Re-engineering the corporation*, HarperCollins, NY
 Harrington J (1984), *Understanding the manufacturing process*, Marcel Dekker Inc.
 Harvey D (1994), *Re-engineering: The Critical Success Factors*, Business Intelligence
 Johansson H J, McHugh P, Pendlebury A J, Wheeler W A (1993), *Business Process Re-engineering- BreakPoint Strategies for market dominance*, J Wiley & Sons
 Kane E J (1986), IBM's Quality Focus on the Business Process, *Quality Progress*, April
 Lefebvre L A, Lefebvre E, Poupart R (1990), The shape of the new winner: Innovativeness and strategic edge in small firms, *National Productivity Review*, Vol 9 No 3
 Meredith J (1987), The strategic advantages of new manufacturing technologies for small firms, *Strategic Management Journal*, Vol 8, pp249-258
 Meyer C (1993), *Fast Cycle Time*, The Free Press, NY
 Mount J, Zinger J T, Forsyth G R (1993), Organising for development in the small business, *Long Range Planning*, Vol 26 No 5, pp 111-120
 Pagoda Associates Ltd (1993), *Pagoda Process Management Report*, London
 Parnaby J (1993), *Business Process Systems Engineering*, Lucas Industries plc, November
 Porter M E (1985), *Competitive Advantage: Creating and Sustaining Superior Performance*,

The Free Press, NY

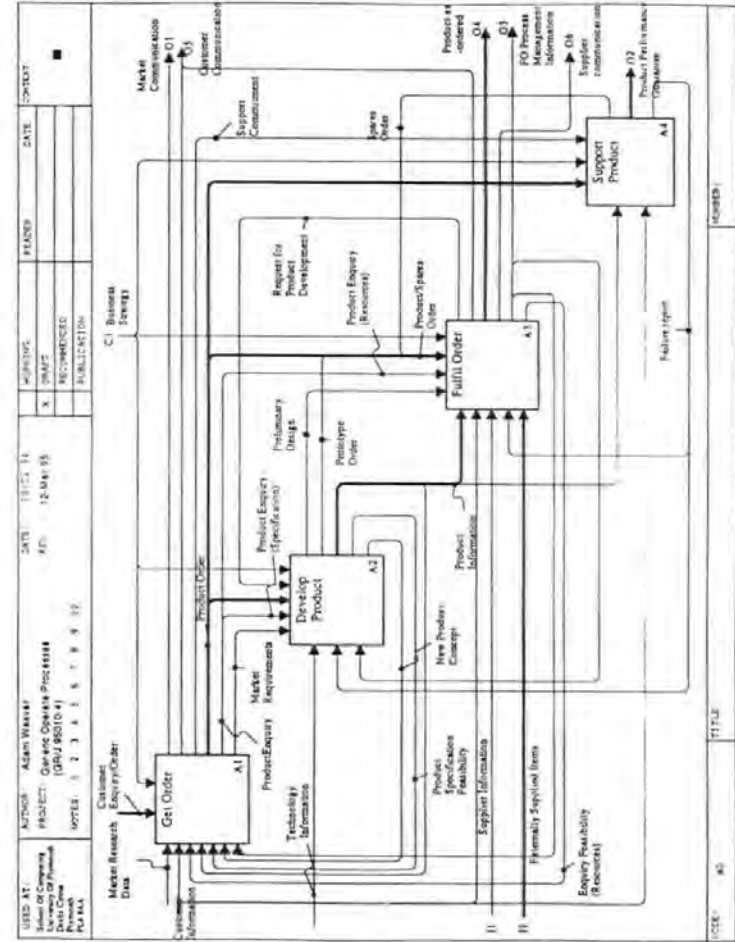
Rummler G A & Brache A P (1990), *Improving Performance*, Jossey-Bass

Shapiro B P, Rangan V K, Sviokla J J (1992), Staple yourself to an order, *Harvard Business Review*, July-August

Veasey P W (1994) Managing a programme of business re-engineering projects in a diversified business, *Long Range Planning*, Vol 27 No5

Wilson B (1984), *Systems: Concepts, Methodologies and Applications*, J Wiley

Wortmann J C (1990), Towards One-of-A-Kind Production: The Future of European Industry, *Advances in Production Management Systems*, Elsevier Science Publishers, Holland



The authors are members of a research team at the University of Plymouth engaged upon various research projects in the field of systems modelling and design in manufacturing and service industries. Current projects are in the areas of business process re-engineering in SME's, production management, concurrent engineering and manufacturing strategy. Current collaborators include manufacturing companies, software companies, financial institutions and hospitals.

Dr Steve Childe is a Postdoctoral Research Fellow in the School of Computing, University of Plymouth. His research interests lie in the area of manufacturing and business systems, including Business Process Re-engineering and Computer Aided Production Management. Dr Childe is a grant holder on EPSRC Grant GR/J95010 "Specification of a BPR Methodology for SMEs". He is a founder member of the European Operations Management Association and a member of IFIP's Working Group 5.7 (Computer Aided Production Management).

DR ROGER MAULL, MR ADAM WEAVER, DR STEVE CHILDE,
MR ANDI SMART, MR JAN BENNETT

School of Computing, University of Plymouth, UK

This paper will provide a framework in which organisations can focus on processes through the adoption of a generic process architecture. The research team at the University of Plymouth have identified three 'sets' of processes; manage, operate and support and have further sub-divided the operate processes into; get order, product development, order flow and after-sales service. Using a Soft Systems approach we describe a root definition and a conceptual model for the order flow process. The paper presents this model.

Although there is significant evidence of the use of generic models in large companies e.g. Xerox Nordic and Shell International, there is little evidence of their application in Small and Medium Sized Enterprises (SMEs). The paper concludes by providing a framework which may be used to establish the suitability of BPR for SMEs.

INTRODUCTION

The latest fad and fashion to arouse the interest of practising operations managers is Business Process Re-engineering (BPR). Interestingly, its take-up has been widespread in both the manufacturing and service sectors with significant success stories being reported by Rover, TSB, ICL, Royal Mail etc. Rummler and Brache [1] have found that managers traditionally have a functional perspective of a business. They state that;

"When we ask a manager to draw a picture of his or her business, we typically get something that looks like the traditional organisation chart."

This view reduces the organisation into component parts e.g. sales, marketing, manufacturing and attention is focused on the effectiveness of each functional specialisation. A process perspective enables managers to visualise the connectivity between each specialisation which is required to meet the requirements of the external customer.

The importance of encouraging individuals at all levels within a company to think in terms of business processes is therefore critical to the success of a BPR project. To achieve this shift in perspective a template based on a hierarchy of generic processes may be utilised to aid the identification of processes within the organisation.

A number of Multi-national companies have successfully used generic process models as a means to help focus on processes as opposed to functions, for example Xerox and Shell. However, there is little research into how Small and Medium Sized Enterprises (SMEs) can use BPR to bring about competitive advantage. The authors are part of a research team based at the University of Plymouth which has been contracted by the EPSRC (UK Research Council) to specify a BPR methodology based around a series of business processes specifically for SMEs.

As a major part of our research project a series of generic process models have been developed. These models may be used to encourage individuals within the business units to think in terms of business processes, and may provide a starting point for process redesign.

RESEARCH METHODOLOGY

The research team have followed a research methodology based on the approach outlined by Meredith [2]. This has three main phases:

Description - reporting and chronicling events and elements of situations. The result is a well documented characterisation of the subject of interest. More detailed descriptive research is known as exploratory research. The result of exploratory research is greater insight and understanding;

Explanation - producing a description of a situation which includes some initial concepts about a situation. If a complex, relatively closed set of relationships is operating then a framework may be constructed. The integration of frameworks helps develop a theory. Theory must improve our understanding of a non-unique phenomenon and must be a non-trivial issue;

Testing (through prediction) - predictions may be postulated and then checked against observation.

The team began the research process by identifying a number of exemplar organisations from those which have been presenting the findings of their BPR work at conferences or which are undertaking BPR projects either in-house or as consultancy operations. These include Lucas Engineering and Systems, Coopers and Lybrand, Rank Xerox and IBM. The purpose of the research within these organisations is descriptive and exploratory, in that an attempt is being made to produce greater insight and understanding by defining, specifying and codifying the field of process identification. To accomplish these aims, semi-structured interviews have been conducted around a general agenda which focuses on:

- Definition of processes;
- Types of change - radical vs incremental;
- Role of IT in BPR;
- Performance measures and BPR;
- Human factor issues in BPR.

The results of this phase of the research were presented at The First European Operations Management Association conference in 1994 [3]. A more detailed working paper is now available from the authors.

DEVELOPMENT OF A GENERIC PROCESS ARCHITECTURE

In the second, explanatory phase of the research, the team have concentrated on what may be regarded as the key first stage in any BPR methodology - the definition of the process. This is very much in accord with documented BPR methodologies such as those developed by Coopers & Lybrand, IBM, British Telecom, Xerox and Lucas. The identification of core processes requires boundaries to be drawn by the participants.

By comparing the core processes produced by companies that have undertaken BPR projects, a set of generic processes becomes evident. This suggests that a set of standard processes may evolve in process oriented organisations, in the same way that a roughly standardised set of functional divisions (manufacturing, design, sales and marketing, finance, personnel, etc.) developed.

Examples of breaking down businesses into varying numbers of processes include Arthur Andersen (200) and Xerox Nordic (48). The difference in numbers of processes can be explained by the level of analysis, the lower number being more abstract. IBM are currently organising their world-wide operations around ten generic internal and external customer facing processes. Lucas Engineering and Systems Ltd have developed a model

containing 16 generic processes. There are further examples of core process definition by companies in both Davenport [4] and the Business Intelligence report [5] on BPR and many case studies in journal articles [6],[7].

The definition of core processes has required extensive investment by the organisations discussed above. The purpose of developing the generic process models described in this paper is to provide small and medium-sized manufacturing enterprises with a similar framework without requiring a disproportionate use of their limited resources.

First level model - manage operate and support

A useful structure established by the CIM-OSA standards committee[8] sub-divides processes into three main areas: Manage, Operate and Support. The CIM-OSA framework regards *manage processes* as those which are concerned with strategy and direction setting as well as with business planning and control. *Operate processes* are viewed as those which are directly related to satisfying the requirements of the external customer, for example the logistics supply chain from order to delivery. These are sometimes referred to as "core processes". *Support processes* typically act in support of the Manage and Operate processes. They include the financial, personnel, facilities management and Information Systems provision (IS) activities.

The initial focus of the authors' work in developing a set of generic processes has been on the operate processes because these are the processes that add value and where greatest gains in competitive advantage can be made [9], [10], [11].

The authors have defined the core operational processes which include, Get Order, Product Development and Order Fulfilment. This is similar to the framework proposed by Champy [12] and Meyer [13]. The "get order" process transforms knowledge of customer requirements and the market into customer orders. The product development process transforms the actual or perceived requirements of a customer into a design that can be manufactured. The order fulfilment process transforms the order by manufacturing and delivering the product to the customer.

The get order process adds value by translating the customer requirements for a product into a form which may be used as a basis for further value adding by the other three operate processes. The product development process adds value for the end customer by using knowledge to design a product to the customer's requirements. The order fulfilment process adds value by manufacturing the product and delivering it to a customer.

The order fulfilment process

The research team have developed a process model of each of the operate processes and have documented the inter-relationships between these core processes. For many companies the most complex of the operate processes is the order fulfilment process.

To develop a rigorous definition of the order fulfilment process, a "root definition" of the process was defined. The concept of a "root definition" is part of the Soft Systems Methodology (SSM) described by Checkland [14]. A root definition should be a "concise description of a human activity system which captures a particular view of it"[15]. Checkland also developed a mnemonic CATWOE by which the six elements that should be covered in a root definition can be remembered. The six elements paraphrased from Checkland are:

- Customers* of the process, beneficiaries or victims affected by the process' activities.
- Actors* or agents who carry out or cause to be carried out the main activities of the process.
- Transformation*, the means by which defined inputs are transformed into defined outputs.
- Weltanschauung*, the outlook or framework that makes the root definition meaningful.
- Ownership*, the agency having a prime concern for the system and the ultimate power to cause the system to cease to exist.
- Environment*, features of the environment of the process that must be taken as given.

The root definition that captures the view of the authors with respect to the order fulfilment process of any manufacturing company is as follows;

The order fulfilment process contains activities performed by humans and machines. Its principal transformations are product orders into products and enquiries into specifications. It includes the flow of both the material and the information that result in the fulfilment of the external customer order or enquiry. The process constantly seeks to fulfil customer requirements whilst balancing stakeholder requirements.

The order fulfilment process is best described through the use of a pictorial model which relates together all these aspects of the root definition (Figure 1.). A description of the model is provided in the section "order fulfilment model".

It is from the root definition in the SSM that a conceptual (pictorial) model is developed. The modelling technique IDEF₀[16] was used to create a conceptual model which represented the root definition. IDEF₀ enables diagrams to be created which explicitly focus on the activities and their connections that collectively represent a process.

IDEF₀ is widely used in the manufacturing and service sectors for modelling processes, it comprises:

- A set of methods that assist in understanding a complex subject;
- A graphical language for communicating that understanding;
- A set of management and human-factor considerations for guiding and controlling the use of the technique.

A comprehensive description of IDEF₀ can be found in the IDEF₀ user manual [17].

The types of flows that are modelled in the generic process model can be divided into physical and information flows. The information flows can be further divided into seven categories of information described by Jorysz and Vernadat [18]. These seven categories of information are

- 1) *Product Information* describes what to produce e.g. drawings, part lists
- 2) *Process Information* describes how the product should be produced e.g. process plans
- 3) *Production Information* describes the quantities to be produced and shop floor progress
- 4) *Planning Information* describes the schedules, inventories and plans
- 5) *Resource Information* describes the facilities that produce the products
- 6) *Administrative information* describes management information e.g. customer orders
- 7) *Organisation information* describes responsibilities

The generic process model includes potential flows between activities representing the first six types of information. Information regarding responsibilities in organisations differ widely thus constraining their inclusion in the generic model. Only in a specific company implementation of the generic can responsibilities be assigned.

Generic flows were identified from IDEF₀ models of manufacturing companies that had been produced by the authors in the course of their research work. Information was also distilled from other models produced in a number of different modelling techniques presented in the literature [19].

Order Fulfilment model

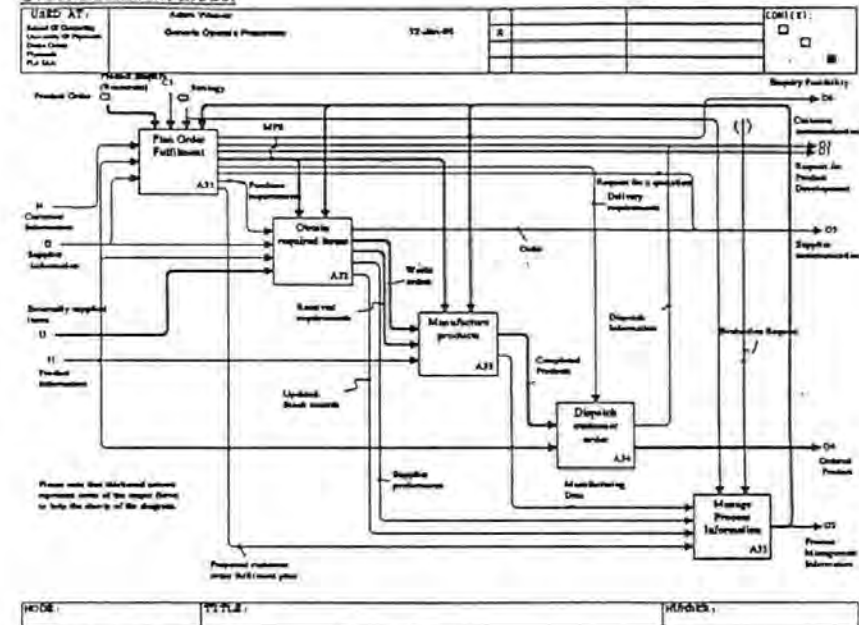


Figure 1.

The generic order fulfilment model includes over 110 activities integrated by both physical and information flows. Figure 1. shows the order fulfilment process from the second of five levels of abstraction. The complete model also includes a glossary of terms.

The information that triggers the process is either a product enquiry or a product order (C3, strategy, is the overall controlling factor for the process). An order (C2) is transformed by the sub-processes until it is dispatched as ordered product (O4). An enquiry enters the process (C1) which results in customer communication (O3) or a request for product development (O1).

The terms used in the model are as generic as possible, for example an "enquiry feasibility report" could represent a verbal "yes" from the Production Manager to the Salesman or a detailed analysis of the capacity requirements, delivery date feasibility and additional capital costs for investment in new tooling presented at a board-level meeting.

The five primary activities represented by the generic model are as follows:

Plan Order Fulfilment

This activity establishes how the company is going to fulfil the customer's requirements. To accomplish this activity Product information (Engineering Drawings and Process Plans), Process Management Information (Resource and Capacity information), Customer Information and Business strategies are all required. The output of the activity is Planning Information and Purchase Requirements.

Obtain Required Items

This activity represents all activities that are involved in acquiring goods and services internally and externally to fulfil a customer's order. Planning Information controls this activity and Product, Supplier and Process Management Information are used. In addition to information flows, the physical items which are required by the activity are also

illustrated. The outputs from this activity are orders to suppliers, together with work orders and externally obtained items which form the input to the next activity.

Manufacture Products

This activity represents the production activities together with the low-level scheduling on the shop floor, the progressing of work through the factory and the monitoring of performance. This activity is controlled by schedules and work orders. It uses Product and Process Management Information (Resources and Capacities) and transforms physical flows of materials into finished products.

Dispatch Customer Order

This activity delivers the finished products to the customer. This activity is controlled by delivery requirements and transforms physical flows of completed products to meet a customer's requirements.

Manage Process Information

This activity gathers supplier performance, manufacturing data, and proposed plans from other activities to give information on process performance and up to date planning and capacity information to ensure the process meets the objectives of the company.

The validation of the generic process model is proceeding as more knowledge is gained through using the model within manufacturing companies. The principal means of validation has been the dissemination of the model to 30 industrialists who have critically evaluated the model.

Application of the generic process models

In the introduction the critical issue of getting employees to think in terms of business processes was identified. The generic process models are intended to be used as an intervention tool to encourage the widespread ownership of a business process framework.

In the stages of the BPR project following the identification of a core process to be redesigned, the participants would be presented with the generic process model and a glossary of terms and asked to compare the generic process model against the company's processes. These activities would be carried out under the guidance of an internal or external facilitator.

In carrying out a comparison the participants would be encouraged to:

1. Think about the business in terms of process flows.
2. Develop a consensus view of their own company's process by debating the differences between the generic model and each participant's perceived view of the company's process.
3. Tailor the generic model to represent their company's process.
4. Identify immediate changes that could be made to the company's process.
5. Consider the effect of any changes on the whole of the process.

The use of generic models enforces a process focus via the application of a process framework. It also provides greater momentum to a project than a "blank sheet of paper" approach[20]. The generic process model is essentially non-political having been produced externally to the company. The non-political nature of the generic process model enables participants to criticise the generic model and in doing so generate debate and understanding amongst the group.

SUITABILITY FOR SME

The third phase of the research has only just begun. This phase concentrates on testing the generic framework in live manufacturing companies - specifically SMEs. A useful summary of the literature for analysing SMEs has been proposed by Mount et al [21]. They describe five typical phases of small business development.

Owner Operated, The owner manages the business and also performs many of the day-to-day productive activities with a small workforce.

Transition to owner-managed, The owner's role is changing to a state in which the owner is engaged in managing the business full-time, yet the business is small enough not to require a middle level of management.

Owner-managed, The owner is engaged full-time in the management activities within the business. Supervisory roles may exist but there are no formal functional boundaries.

Transition to emergent functional The company is becoming too big to be managed by the owner. Functional boundaries become defined and hence a middle layer of management is required. The addition of specialist middle managers demands substantially more delegation of decision making. In this case the owner is often obliged to screen the viewpoints of senior functional managers and to arbitrate some consensus on a final course of action.

Functional organisation A company in which defined functions and managers and a clear organisation structure exists. Middle management is established and functions have established their own objectives, mission statements etc. There may be a conflict of interest between functions, and political manoeuvring may be widespread.

The research team have made research visits to twelve SMEs which have been classified in the Mount framework. Early results indicate that in organisations in phases one, two and three the owner exhibited control by being intimately involved in customer requirements and orders and consequently had a thorough understanding of the whole customer supply chain. However, in those organisations which were moving into, or had established, an emergent functional organisational form, it was much more difficult for owners (or CEOs) to have a clear picture of the whole organisation and its constituent processes. It would appear to be in these organisations, which have lost sight of the processes and which manage and measure performance by function, that a process focus may provide real benefits.

For example, in two companies, both employing 250 staff, two different organisational types have emerged. Company A had a problem with the speed of order entry and the speed with which an order was released to the shop floor. The MD was able to convene a meeting of all the staff involved, establish stretch goals and facilitate a genuine holistic approach to process analysis. This company was still essentially owner managed, and functional sub-division was not culturally embedded.

In Company B with a similar planning problem, functions had emerged, were established and indeed encouraged. The MD had way of identifying cross functional problems, he was unable to identify order entry/works order release issues. In this type of organisation a generic model is invaluable. It provides the MD with a tool around which he can analyse his problems as a "whole", and concentrate on areas for change. He can then convene cross functional teams and look for bureaucracy, inspection/exception routines etc.

The essential difference between the two cases is that in Company A the MD was always taking a "whole" process perspective, whereas in Company B the organisation's structure was configured to make this almost impossible.

CONCLUSION

The objective of the paper was to describe the development of a generic process model and its application within SMEs. The definition of core processes depends upon the level of abstraction that the organisation finds meaningful. In this paper a generic set of activities has been provided in abstract form which every manufacturing company performs in fulfilling an order. A process architecture for manufacturing companies provides a framework to encourage a process perspective. The generic process model is to be used as

an intervention tool for companies which are less able to invest resources in the definition of core processes themselves.

The real challenge with SMEs is to change mindsets - to begin to convince their opinion formers of "knowing what they don't know". A process perspective provides a real opportunity for SMEs to change, based on processes and external customers rather than functional division. The test of the process model is how successful it will be in changing minds and re-focusing SMEs not just on efficiency and cost reduction but also upon enhancing service to the customer.

ACKNOWLEDGEMENTS

The research work described in this paper has been jointly funded by the UK Engineering and Physical Science Research Council and British Aerospace (Systems and Engineering) Ltd. under a grant (GR/J95010) entitled "The Specification of a Business Process Re-engineering Methodology for Small and Medium Sized Manufacturing Enterprises"

REFERENCES

- [1] Rummler G A & Brache A P, *Improving Performance - How to manage the white space on the organisational chart*, Jossey-Bass Publishers, 1990.
- [2] Meredith J, Raturi A, Amoako-Gyampah K, Kaplan B, Alternative Research Paradigms in Operations, *Journal of Operations Management*, Vol.8 No.4, 1989
- [3] Weaver A, Maull R, Childe S and Bennett J, State of the Art in Business Process Re-engineering in UK Manufacturing Companies, *1st European OMA Conference*, Cambridge June 27-29 1994
- [4] Davenport T H, *Process Innovation: Re-engineering Work Through Information Technology*, Harvard Business School Press, 1993
- [5] Harvey D, *Re-engineering: The Critical Success Factors*, Business Intelligence, 1994
- [6] Shapiro B P, Rangan V K, Sviokla J J, Staple yourself to an order, *Harvard Business Review*, July-August, 1992
- [7] Davenport T H and Short J E, The new industrial engineering: information technology and Business Process Redesign, *Sloan Management Review*, Summer, 1990.
- [8] CIM-OSA Standards Committee, CIM-OSA Reference Architecture, *AMICE ESPRIT* 1989.
- [9] Hammer M & Champy J, *Re-engineering the corporation: A manifesto for business revolution*, HarperCollins Publishers, NY, 1993.
- [10] Meyer C, *Fast Cycle Time: How to align purpose, strategy, and structure for speed*, The Free Press, 1993
- [11] Johansson H J, McHugh P, Pendlebury A J, Wheeler W A *Business Process Re-engineering - BreakPoint Strategies for market dominance*, J Wiley & Sons, 1993.
- [12] Champy J, *Re-engineering Management*, HarperBusiness, NY, 1995.
- [13] see ref. [9]
- [14] Checkland P, 1981, *Systems Thinking, Systems Practice*, J Wiley & Sons
- [15] see ref. [14]
- [16] LeClair S R, IDEF the method, architecture the means to improved manufacturing productivity, *SME Technical Papers MS82-902*, Society of Manufacturing Engineers USA 1982
- [17] see ref. [16]
- [18] Jorysz H R, Vernadaf F B, CIM-OSA Part 2: Information view, *International Journal of Computer Integrated Manufacturing*, Vol.3, No.3, 1990, pp.157-167.

[19] Harington J, *Understanding the manufacturing process*, Dekker 1984

[20] Hammer M, Reengineering work: Don't automate obliterate, *Harvard Business Review*, July-August, 1990

[21] Mount J., Zinger T., and Forsyth G. R., 'Organising for development in small business', *Long Range Planning*, Vol. 26 No. 3, 1993, pp. 111-120.

Autofact / ... Singapore

THE DEVELOPMENT AND APPLICATION OF A GENERIC "ORDER FULFILMENT" PROCESS MODEL

A M WEAVER, S J CHILDE, R S MAULL, P A SMART
School of Computing, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK
E-mail : adamw@soc.plym.ac.uk

and

J BENNETT
Teaching Company Centre, University of Plymouth

Abstract

The objective of this paper is to describe how generic process models can be used as a technique within an approach to Business Process Re-engineering that will encourage companies and participants carrying out BPR projects to take a business process perspective. The definition of core processes within organisations is identified as common practice in BPR projects. The paper proposes the development and validation of a set of generic process models to provide a process framework and intervention tool for BPR projects within Small and Medium Sized Manufacturing enterprises.

The development and validation of a generic process model representing the "order fulfilment" process of a manufacturing company is used as an example. IDEFo is used to develop the model. A method of using the generic process models as intervention tools is outlined and its advantages are described.

1. Introduction

"If you want to understand the way work gets done, to improve the way work gets done, and to manage the way work gets done, processes should be the focus of your attention and actions. Viewing issues from a process perspective often reveals a need to make radical changes in goals, in the design of business systems and the management practices." Rummler & Brache (1990)

Rummler and Brache describe the essence of Business Process Re-engineering (BPR) i.e. viewing the issues in an organisation from a business process perspective and changing the design of business systems and management practices.

In recent surveys between 65% and 77% of respondents were carrying out or considering Business Process Re-engineering (BPR) projects. The popularity of BPR suggested by these figures is backed up by an abundance of literature, seminars, conferences and software tools that have emerged over the past few years.

In their survey (Skinner and Pearson 1993), Highams Systems Services Group Ltd, found that the respondents to the survey were implementing BPR projects for a number of reasons. The list of reasons given included "the need for continuous improvement", "increased customer expectations", "increased competition" and "changing market needs". The benefits that these companies hoped to achieve were again various, "increased customer focus", "improved profitability" and "improved corporate flexibility" all featured high on the list of benefits.

A Business Intelligence survey found that their respondents had mixed experiences of using BPR, in fact, "few have succeeded in transforming their total

operations" (Harvey 1994). Business Intelligence refer to a number of possible reasons for the mixed experiences including weaknesses at any stage of the methodology resulting in partial or complete failure, corporate cultural barriers and lack of a sound business strategy.

The objective of this paper is to describe how generic process models can be used as a technique within an approach to BPR that will encourage companies and participants carrying out BPR projects to take a business process perspective. The authors believe that the issue of how to encourage individuals at all levels within a company to think in terms of business processes is critical to the success of a BPR project. This is reinforced by Rummler and Brache who have found that;

"When we ask a manager to draw a picture of his or her business (be it an entire company, a business unit or department), we typically get something that looks like the traditional organisation chart." (Rummler and Brache 1990)

2. Definition of Business Processes

In the majority of documented BPR methodologies, including those developed by Coopers & Lybrand (Johansson et al 1993), IBM (Kane 1986), British Telecom (Harvey 1994), Xerox and Lucas (Parnaby 1993), one of the initial activities is to identify the core business processes. In identifying the core processes the participants in the BPR project are defining boundaries within their organisation using a process perspective.

It is useful to compare a business process to a system. A system embodies four basic ideas; which paraphrased from Checkland (1981) are emergent properties, a hierarchical structure, communication between entities within the system and a process of control. A business process embodies the same four basic ideas. For example products and information are emergent properties of a business process since they are a result of the overall interaction of the entities within the process; a business process can be decomposed into a hierarchy of sub-processes; there are flows of information and physical entities within a business process connecting the entities and the process is managed.

The basic idea of a hierarchy of processes is important when considering generic processes for an industry type and the core processes within a company. The hierarchy of processes provides the framework within which the analysis and redesign will take place. The number of core processes within a company is very much dependant on the level of abstraction at which the organisation decides the core process definition will be meaningful. Business Intelligence's report (Harvey 1994) provides a table of the core process taxonomies of a number of consultants, the numbers ranging from 7 to 20 core processes.

Examples of breaking down businesses into varying numbers of processes include Arthur Andersen (200) and Xerox Nordic (48). The difference in numbers of processes can be explained by the level of analysis, the lower number being more abstract. Other companies where the definition of core processes was evident and was being used at senior management level in the initial stages of a BPR project include IBM which is

currently organising its world-wide operations around ten generic internal and external customer facing processes and Lucas Engineering and Systems Ltd, who have developed a model containing 16 generic processes. There are further examples of core process definition by companies in both Davenport (1993) and the Business Intelligence report (Harvey 1994) on BPR and many case studies in journal articles (Shapiro et al 1992, Davenport and Snort 1990).

The prospect of managing businesses in a process organisation may lead to the evolution of standard processes, in the same way that a roughly standardised set of functional divisions (manufacturing, design, sales and marketing, finance, personnel, etc.) developed.

The definition of core processes has required extensive investment by the multi-national organisations discussed above. The purpose of developing the generic process models described in this paper is to provide small and medium-sized manufacturing enterprises with a similar framework without requiring the use of their limited resources. The generic process models described provide a framework and the detail of the generic process models provides the ability for the models to be used as an intervention tools in a BPR approach.

3. The development and validation of the generic "order fulfilment" process model

3.1. *The level of analysis*

The first objective is to establish the level of analysis or "bound" the model. For the generic model to be of any use it must contain elements which are at a level of abstraction that allows meaningful discussion. Breaking a major business process into 5-10 generic activities and flows would not provide a catalyst for comparison with a company's existing process. Conversely the generic model should not be at a level of abstraction where much of the model is irrelevant to any particular company.

For a generic model to act as an intervention tool to encourage participants in a BPR project to take a process perspective and work with the model as a framework for improvement, it must model a process that is key to the success of the business. The generic process model described in this paper is a model of the "order fulfilment" process within a manufacturing company. The model has been developed in discussions with a number of manufacturing companies varying in size from Times 1000 companies to Small and Medium Manufacturing Enterprises (SMEs) with under 500 employees.

The generic process model of the "order fulfilment" process will cover all four types of manufacturing companies defined by Wortmann (1990); Make-to-stock, Assemble-to-order, Make-to-order and Engineer-to-order. During discussions with companies it was evident that different companies place different emphasis on parts of the "order fulfilment" process. For example a local company that can be classified as engineer-to-order places considerable emphasis on the preliminary stages of the order fulfilment process where the company works closely with the customer to specify the product and plan the manufacture of the product. Another local company that can be

classified as make-to-stock considers the activities immediately before shipping to be of particular importance.

3.2. The Modelling Technique

The generic model of the "order fulfilment" process has been developed using IDEFo (CAM-1 1980). IDEFo is widely used in the manufacturing sector for modelling processes. IDEFo comprises:

- A set of methods that assist in understanding a complex subject;
- A graphical language for communicating that understanding;
- A set of management and human-factor considerations for guiding and controlling the use of the technique.

IDEFo uses top-down decomposition to break-up complex topics into small pieces which can be more readily understood. An IDEFo model is an ordered collection of diagrams. The diagrams are related in a precise manner to form a coherent model of the subject. The number of diagrams in a model is determined by the breadth and depth of analysis required for the purpose of that particular model. At all times the relationship of any part of the whole remains graphically visible.

In summary IDEFo provides the ability to show what is being done within a process, what connects the activities and what constrains activities. It uses a structured set of guidelines based around hierarchical decomposition, with excellent guidance on abstraction at higher levels. If used well this ensures good communication and a systemic perspective.

3.3. Information used to develop the generic model

The information used to develop the generic process model has been extracted and assimilated from a number of sources. The activities that are carried out within the "order fulfilment" process were adapted from a generic task model developed by Childe (1991). Childe's task model was based on the proposition that there are a key set of tasks or activities which are consistent throughout manufacturing companies (all manufacturing companies order materials, take orders from customers etc.). The task model does not show any information or physical flows and hence it does not show how the activities within a manufacturing company may be integrated horizontally to produce an output. However it did provide a validated model of activities from which to develop a generic process model of the "order fulfilment" process.

The physical and information flows that integrate the activities to form the "order fulfilment" process were identified by using IDEFo models of manufacturing companies that had been produced by the authors in the course of their research work. Information was also distilled from other models produced in a number of different modelling techniques, from literature and from the experiences of the authors while working with manufacturing companies.

3.4. Validation of the generic process model

The validation of the generic process model is on-going as more knowledge is gained through using the model within manufacturing companies. Validation includes the criticism and comment by academic colleagues, a comparison by third parties to their own generic models of the "order fulfilment" process and experience gained by applying the generic process model as an intervention tool within manufacturing companies interested in BPR.

The generic process model of the "order fulfilment" process currently includes over 110 activities integrated by the flows of physical and information entities. Fig 1. shows the second highest level of abstraction of the "order fulfilment" process. The model extends to 5 lower levels of activities and flows. The complete model also includes a glossary of terms.

4. The application of generic process models

In the introduction the critical issue of getting employees to think in terms of business processes was identified. The generic process models are intended to be used as an intervention tool to encourage the participants of a BPR project within a manufacturing company to take a business process perspective. The participants in a BPR project would generally be individuals from the functions who currently perform activities within the process guided the objectives set by senior management.

In the initial stages of the BPR project following the identification of a core process to be redesigned, the participants would be presented with the generic process model and glossary of terms and asked to compare the generic process model against the process within the company that the model is intended to represent. In carrying out a comparison it encourages the participants to:

1. Take a business process perspective as the generic model provides an existing process framework.
2. Develop a consensus view of their own company's process by debating the differences between the generic model and each participants perceive view of the company's process.
3. Identify and change the generic model to represent their company's process.
4. Identify immediate changes that could be made to the company's process as differences between the model and reality are found.
5. Consider the systemic relationship of all parts of the process as IDEF0 provides a structured medium where inconsistencies in the changed model can be identified easily.

In comparison with current BPR approaches where the participants are encouraged to develop a process model of the existing business process, it reduces the danger of participants reverting to tradition functional thinking by providing a process focused framework. It also provides greater momentum to the project than a "blank sheet of paper" and the generic process model is non-political having being produced

externally. The non-political nature of the generic process model should enable participants to more freely criticise the generic model and in doing so generate debate and understanding amongst the group.

5. Conclusion

The objective of the paper was to describe the development of generic process models and their application within small and medium sized manufacturing enterprises. A generic process model of the "order fulfilment" process was chosen as an example following considerable interest expressed by companies visited during the research project.

The definition of core processes is dependent on the level of abstraction that the organisation finds meaningful. There has been substantial investment by many multinationals in defining core processes within their organisations. The identification of an "order fulfilment" process is a commonly defined across many different sectors of industry. A set of generic process models of core processes within manufacturing companies would provide a framework to encourage a process perspective in companies less able to invest resources in the definition of core processes and could be used as an intervention tool.

The generic process model was developed using IDEF0. IDEF0 provided structured approach, hierarchical decomposition and medium to enable easy of communication of the model.

The application of generic process models in SMEs as part of a BPR project encourages a process perspective to be taken by participants, provides an additional momentum to the project and encourages debate and understanding of the existing process within the company.

Acknowledgements

The research work described in this paper has been jointly funded by the Engineering and Physical Science Research Council under a grant (GR/J/95010) entitled "A specification of a Business Process Re-engineering methodology for Small and Medium Sized Manufacturing Enterprises" and British Aerospace (Systems and Engineering) Ltd.

The generic process model was developed using DESIGN/IDEF supplied by IDEFine Ltd.

References

- CAM-I (1980), *Architect's Manual ICAM Definition Method "IDEF-0"*, Arlington, Texas
- Checkland P (1981), *Systems thinking, systems practice*, J Wiley & Sons

Childe S J (1991), *The design and implementation of manufacturing infrastructure*, PhD Thesis, Polytechnic South West, UK

Davenport T H and Short J E (1990), The new industrial engineering: information technology and Business Process Redesign, *Sloane Management Review*, Summer

Davenport H J (1993), *Process Innovation*, Harvard Business School Press

Harvey D (1994), *Re-engineering: The Critical Success Factors*, Business Intelligence

Johansson H J, McHugh P, Pendlebury A J, Wheeler W A (1993), Business Process Re-engineering- BreakPoint Strategies for market dominance, J Wiley & Sons

Kane E J (1986), IBM's Quality Focus on the Business Process, *Quality Progress*, April

Parnaby J (1993), Business Process Systems Engineering, Lucas Industries plc, November

Rummler G A & A P Brache A P (1990), *Improving Performance - How to manage the white space on the organisation chart*, Jossey-Bass Publishers

Shapiro B P, Rangan V K, Sviokla J J (1992), Staple yourself to an order, *Harvard Business Review*, July-August

Skinner C & Pearson J R W (1993), *Business Process Re-engineering in the UK Financial Services Industry*, Highams Systems Services Group Ltd

Wortmann J C (1990), Towards One-of-A-Kind Production: The Future of European Industry, *Advances in Production Management Systems*, Elsevier Science Publishers P.V. Holland

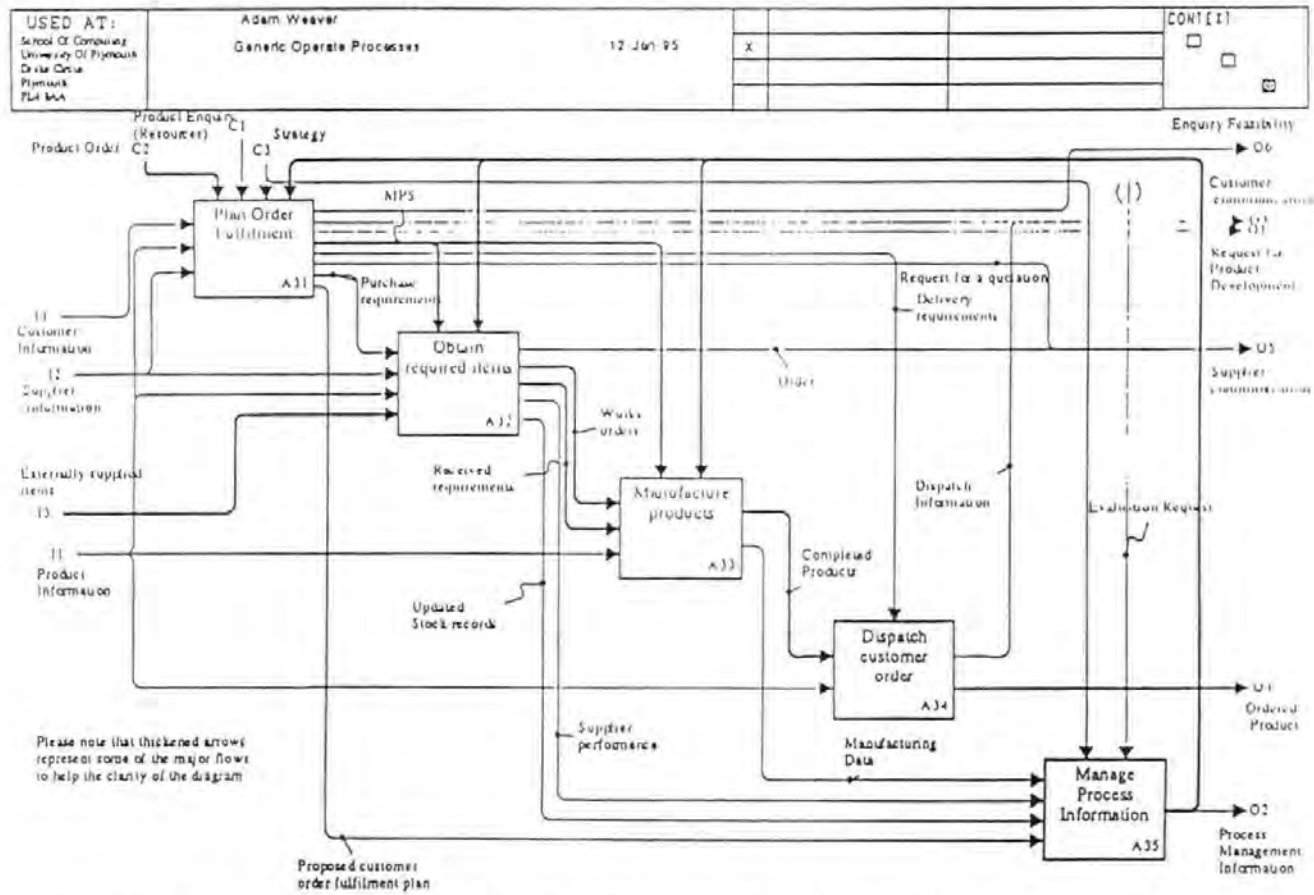


Figure 1. IDEF0 Diagram of the 2nd Level of abstraction of the Generic "Order Fulfilment" Process

The use of generic process models for process transformation

S J Childe, P A Smart, A M Weaver
University of Plymouth
Plymouth, PL4 8AA, U.K.,
Tel. +44 1752 232618, Fax +44 1752 232540,
Email s.childe@plymouth.ac.uk

Abstract

The paper extends the work presented previously on the application of generic process models in Business Process Re-engineering (Childe *et al* 1995). The construction of business process models is contextualised by a five stage composite methodology for BPR. Following an analysis of various process architectures the potential of generic process models is presented. The development of such a model is described. The application of this model in a small manufacturing company is discussed and the areas in which the model proved to be useful are shown. The paper challenges traditional sequential methodologies and suggests a non-sequential orientation and the systemic consideration of six fundamental issues. The paper reports on the current thinking in the area of delivery mechanism development for BPR methodologies. This thinking focuses predominantly on learning and the transfer of relevant expertise to practitioners.

Keywords

Business Process Re-engineering, methodology, process modelling, generic model

1. INTRODUCTION

Over the past five years, Business Process Re-engineering (BPR) has emerged as a popular approach used by organisations seeking improvements in their business performance. This interest began with Hammer and his seminal article entitled 'Re-engineering work: Don't Automate, Obliterate' (Hammer 1990). Surveys by Highams Systems Services Group (Skinner & Pearson 1993) and Business Intelligence (Harvey 1994) report that 65% and 77% respectively of respondents were carrying out or considering Business Process Re-engineering activities. In their survey, Highams Systems Services Group Ltd found that the respondents to the survey were carrying out BPR projects for a number of reasons. These included:

- 'the need for continuous improvement'
- 'increased customer expectations'
- 'increased competition'

- 'changing market needs'

This survey revealed that many companies believe there are a variety of possible benefits to be gained from organising around business processes. However, it also identified that there are many risks associated with BPR projects. It is apparent that no single BPR methodology of those in use by practitioners has been identified as more successful than the others.

BPR's rise to prominence as a powerful means of transforming business performance has led to the emergence of a number of 'gurus' in the field, the most notable of whom are Hammer (1990), Harrington (1992) and Davenport (1993).

Hammer's intervention strategy, the 'neutron bomb' approach to business improvement (Hammer & Champy 1993) 'We'll leave the walls standing and we'll nuke everything on the inside', represents one extreme of a wide spectrum of opinion regarding the most appropriate BPR strategies for firms to adopt. Hammer states, for example, that firms can only hope to achieve radical performance improvements using Business Process Re-engineering methods which strive to 'break away from the old rules about how we organise and conduct business.' He states that re-engineering cannot be accomplished in small or cautious steps but must be viewed as an 'all-or-nothing proposition.'

Davenport shares this view but concedes that, in practice, most firms will need to combine incremental and radical improvement activities in an ongoing quality programme. He states that before striving for process innovation, a firm will ideally (though not necessarily) attempt to stabilise a process and begin continuous improvement (Davenport 1993).

At the other end of the spectrum, Harrington (1992) takes a more incrementalist view. He prefers to use the term Business Process Improvement which he defines as a 'systematic methodology developed to help an organisation make significant advances in the way in which its business processes operate'.

The dramatic rise in interest in BPR over the past few years has resulted in a plethora of information, opinions and perspectives on all aspects of BPR.

2. METHODOLOGY FOR BPR

The synthesis of many approaches that companies and consultants use for BPR has resulted in the identification of a five stage composite methodology (Maull *et al* 1995a).

phase 1	Identify or create corporate, manufacturing and IT strategies
phase 2	Identify key process(es) and performance measures
phase 3	Analyse existing process(es)
phase 4	Redesign and implement process(es)
phase 5	Monitor and continuously improve new process(es)

From the experiences of practitioners in the UK it is evident that the majority of effort is expended in phases two and three of the methodology. In the main, these phases require the identification of process boundaries, and the construction of 'as-is' process models highlighting current business situations.

3. PROCESS MODELLING

Process models are used to facilitate an organisation's understanding of 'how' it currently operates and 'what' it actually does. To investigate the way in which business processes may be constructed it is necessary to define what a process is. There are many varying definitions (Davenport 1993, Harrington 1991) of what a business process is, but they generally fail to provide the detail required for identifying process characteristics.

3.1 Process Characteristics

Our research into process characteristics has been heavily influenced by the work of Churchman (1971) and Checkland (1981) in the domain of Systems Theory. In our view the concept of a business process within BPR is synonymous with the concept of a system (Weaver *et al* 1994).

A business process is not the same as a function. The people and operations we include in a single business process may come from more than one traditional functional group. A business process can be identified by the business object which flows through it (Childe *et al* 1994).

From this perspective of a business process, it is possible to treat a business process as a purposeful system. In this system (business process) the route to improving its efficiency and effectiveness is the way in which the human resource utilises the physical resources available (Checkland 1982). Therefore these systems or business processes represent Human Activity Systems (HAS). A HAS represents 'a set of human activities, linked together so that the whole constitutes purposeful activity' (Checkland 1981).

Systems theory offers various concepts which can be useful for the construction of process models. A useful approach is to consider a system in terms of its parameters (Churchman 1971) namely the: Source; Input; Transformation; Process; Output; Receiver; Feedback.

When applying these parameters, analysts may become aware that they are making assumptions about a number of systems concepts, namely:

- Objectives/purpose;
- Weltanschauung (Worldview);
- Boundaries;
- Resources;
- Management.

Typical Business Process Re-engineering approaches make a number of assumptions about these concepts which are consistent with a hard systems view. Hard systems approaches assume a common *Weltanschauung* regarding 'where are we now', a defined set of objectives 'where do we want to go' and, therefore, a means for identifying the action space for change. The weakness in this approach is that business processes represent Human Activity Systems which have a multiplicity of Objectives and *Weltanschauungs* (Checkland 1981). Consequently the definition of system boundaries, resources and management is highly problematic.

3.2 Framework for analysis

A useful framework which may be employed to consider the characteristics of a process are:

- *The development of consensus regarding Weltanschauungs and objectives.* Techniques must provide an easy to use/common language for communication and debate. The success of the technique depends upon the simplicity of the syntax and semantics employed by the technique. Consensus needs to be established regarding system boundary and purpose (Root Definition). In addition, a coherent set of modelling rules is required to facilitate the modelling process itself;
- *The description of a process in terms of systems parameters.*
- *The identification of a systems hierarchy.* The idea of hierarchy is based on a systems concept in which systems are composed of sub-systems (and processes of sub-processes). Harrington (1991) has proposed a hierarchy of macroprocesses, sub-processes, activities and tasks each of which represents further hierarchical detailing of the process. Techniques must facilitate the identification of sub-processes, activities and tasks within the whole process, so that each element of the system is seen in its proper context relative to the other elements, and the analyst can identify the impact of any change upon the whole business system.

This framework provides the basis for the identification of appropriate process modelling and analysis techniques for a company.

3.3 Representing a business process using a model

The first stage of the analysis of a business process is concerned with constructing a model of the business process. It usually involves the change team modelling the existing or 'as-is' business process.

Each model will relate to a particular *Weltanschauung* of the business process. The creation of an 'as-is' business process model allows the change team to establish common ground and develop a consensus viewpoint. As the change team participates in modelling the 'as-is' business process, they begin to understand what is wrong with it and let go of their attachment to it.

The benefits of developing a business process model do not necessarily result from having a complete or totally accurate model. The benefits are more likely to result from the change team communicating their understanding. Successful communication of each perspective will enable the creation of a model that represents a consensus.

One of the greatest problems facing most organisations is not deciding what to do differently, but developing the critical momentum required to change existing behaviour. The act of creating a business process model that represents a consensus view can help to develop that critical momentum. It is therefore essential to focus on the modelling of the business process prior to its analysis.

We have established that the creation of a business process model is an important activity in the overall BPR project. However, the construction of process models is a resource-intensive activity. This problem may be overcome by utilising a set of generic models which may be adapted to fit specific company scenarios.

4. GENERIC MODELS

One of the initial activities of a BPR methodology is the identification of core business processes. This was briefly described in Section 2. In identifying the core processes the participants in the BPR project are defining boundaries within their organisation from a process perspective.

4.1 An architecture of Business Processes

The notion of architecture and hierarchy of business processes is discussed by Maull *et al* (1995b). The provision of a hierarchical architecture both facilitates and simplifies the development of a process model.

If the organisation is regarded as a single process, the representation of the whole process may be described as level 0, the most abstract and general level. At the next level in the hierarchy greater process detail is presented. Reported cases identify between 10 and 20 business processes at this level. Business Intelligence's report (Harvey 1994) provides a table of the core process taxonomies of a number of consultants ranging from 7 to 20 core processes. A number of leading organisations have identified between 10-20 processes at level 1 including BT with 15 processes, Xerox with 11 processes and IBM with 10 processes.

Some authors describe a level 1 of between 3 and 5 processes, with between 10 and 20 processes at level 2. Parnaby (1993) describes 3 processes at level 1 and 16 at level 2 at Lucas. Other similar hierarchies are described by Pagoda (1993), Harrington (1984), Veasey (1994).

Porter (1985) identifies 'primary' and 'support' activities in his 'value chain' concept. The 'primary activities' are essentially value adding from an external customer perspective, and 'support activities' are those that enable the primary activities to function.

The CIM-OSA standard provides a recognised framework around which to group the processes identified by organisations. The first two types of processes are the 'Operate' processes that add value and the 'Support' processes that enable the 'Operate' processes to function. 'Operate' processes are viewed as those which are directly related to satisfying the requirements of the external customer, for example the logistics supply chain from order to delivery. A detailed description of the 'Operate' dimension of the framework is discussed in Maull *et al* (1995b). The 'Support' processes include the financial, personnel, facilities management and information systems provision activities. The third type of process, the 'Manage' processes, are the processes that develop a set of business objectives, a business strategy and manage the overall behaviour of the organisation.

The grouping of the processes under 'Manage, Operate and Support' provides a framework for the classification of process types.

4.2 An IDEF₀ model of standard business processes

The development and validation of a model of four standard business processes that may be classified as 'Operate' processes is described by Maull *et al* (1995). In this document the model and guidelines for its use are included as an appendix.

The purpose of developing and validating a set of standard business models was to help individuals in a manufacturing company identify and understand their key business processes.

The IDEF₀ model created represents four 'Operate' processes. The model shows the interactions between each of the processes and external customers, suppliers and other parts of the organisation that are outside the boundaries of the high level processes. IDEF₀ allowed a model of each process to be developed separately and then combined into a single model of the 'Operate' processes. The model includes a set of IDEF₀ diagrams and a glossary of terms.

The completed model represents an integrated set of over 180 different activities and over 250 different flows. The model extends to six levels of decomposition. It does not show who or what performs any of the activities represented. For a specific organisation the identification of who or what performs an activity could be one of the first stages of adapting the standard model to represent their own business processes.

The model may include activities that would be removed or changed in the vast majority of re-engineering projects, for example inspection activities. The only criterion for including activities and flows in the model was that the activity or flow under consideration would normally form part of the business process in a *typical* manufacturing organisation. The model is not intended to represent 'best practice'.

4.3 Validation of the model

The model has been validated in two stages. The first stage was to ensure that the model represented a consensus view of the 'Operate' processes in a typical manufacturing company. The second stage was to ensure that the model could be used to help a manufacturing company gain an understanding of their business processes.

4.4 Assessment of the model by practitioners

The first stage of the validation involved the assessment of the model by practitioners. Over 85 copies of the model were distributed to practitioners who had responded to a series of requests for reviewers. Of the 85 practitioners who received the model for review, 29 provided feedback. The reviewers were employed in a variety of areas including manufacturing organisations, consultancy and academia and many were outside the UK.

The feedback provided by the reviewers was positive and many issues raised were acted upon to improve the model. The main issues included:

- Alterations that needed to be made to the model;
- Complexity of the model;
- Review of some of the terms used to avoid any ambiguity;
- Explicit statement of the viewpoint from which the model was created;
- The type of manufacturing companies to which the model was applicable;
- The use of IDEF₀ as the modelling technique.

4.5 Use of the model in a local manufacturing company

The second stage of the validation involved the use of the model by the management of a local manufacturing company to understand their key processes and develop an 'as-is' model of their 'order fulfilment' process.

A single briefing on how the model was intended to be used was presented to the IT manager of the company. The IT manager recounted his experiences in using the generic model after the development of an 'as-is' model had been completed.

During a series of interviews with key personnel the IT manager used the model to discuss activities carried out by the interviewee, the flows between activities and the context of the activities within an overall order fulfilment process ('Walking through' the process). The discussion resulted in a common understanding and view of what was happening within the company as part of the process.

The IT manager identified four main areas in which the model had proved useful to the company. These areas were:

- allocation of responsibility - adding mechanisms to indicate who was responsible for activities initiated discussions about who was and should be responsible for activities and supplying information.
- taken for granted - by 'walking through' the process discussions about activities that had not been properly considered before were initiated.
- ideas for improvement - some activities shown on the model were not carried out by the company. After further discussions it was decided that the company would benefit from carrying out these activities.

- time saving - the IT manager stated that developing an 'as-is' model using the standard process model took considerably less time than developing an 'as-is' model from a 'blank sheet of paper'.

The company did make a number of recommendations concerning improvements to the model. They are currently using the models as a basis for specifying a new CAPM system.

The generic models may be seen to facilitate the identification of core processes and the construction of process models. The generic model is not a prescriptive solution, or a representation of best practice. Rather, it is a tool which may be used to help and support manufacturing companies in their BPR programmes. As indicated in section 2, the second phase of a BPR methodology is typically concerned with the identification and modelling of core processes.

5. FOCUS OF BUSINESS PROCESS RE-ENGINEERING

Research conducted in four case study companies and the visits to four leading organisations provided some insight into the typical focus of BPR programmes (Maull *et al* 1995a). Despite the variations in size, complexity and industrial sector, a set of fundamental issues were found. These issues can be described under six main headings;

- scope of change
- performance measures
- information technology
- human factors
- business process architecture
- strategy for BPR

In our view each company was having to address these issues at some point in the life cycle of their BPR project. Strict adherence to the set of general methodological phases presented in Section 2 may be in danger of misleading BPR practitioners. A company may go through each phase assiduously yet never consider fully the six issues now identified. This will affect the way in which the methodology is implemented. For example, a process architecture structure aids the identification of processes in Phase Two of the methodology. It also helps the analysis of these processes and acts as a catalyst in Phase Three. Thus the existence of a process architecture will affect the way the BPR project is carried out.

Similarly a focus on radical rather than incremental change may be concerned with phase three (re-design), and may not require the analysis of existing processes. Organisations may focus their attention exclusively on incremental product based processes and omit any strategic considerations. Others may focus on developing an infrastructure for change based around flexible working. A Benchmarking project may use a process structure (Childe and Smart 1995) without articulating any methodology. Thus there is a need to challenge the step by step

nature of these methodologies. Two essential aspects of a BPR methodology need to be addressed;

1. A non-sequential orientation.
2. Systemic consideration of the six issues identified.

6. POTENTIAL DELIVERY MECHANISM

Research is being undertaken to identify appropriate delivery mechanisms for a BPR methodology. The issue of a non-sequential approach may be accommodated in a computer based tool designed on a hypermedia structure. The functional perspective of hypermedia is that it has a node and link structure which enables the user to explore its content in a non-linear fashion (Knussen *et al* 1991).

Ensuring the systemic consideration of the six issues identified, the education of the members of the change team may need to be addressed. In addition to the non-sequential structure provided by hypermedia, it is recognised that the processes of association and exploration that are vital to learning and maintaining user motivation are also facilitated by a hypermedia structure.

Historically, the capabilities of the emerging and evolving technologies have been used as the basis for the design of learning sequences irrespective of any model of learning. Consequently many instructional technologies have yielded disappointing results (Hannafin and Philips 1987). It is therefore important to consider research in the field of education, specifically models of instructional design, prior to the design and development of learning mechanisms for BPR.

7. CONCLUSION

This paper has addressed the development and use of generic process models for manufacturing enterprises. Following rigorous validation of four process models classified as 'Operate' processes the models were applied in an industrial company. The models were found to be useful by this company in the areas of; the allocation of responsibility, addressing taken for granted assumptions, the provision of ideas for improvement, and the time saved in constructing process models.

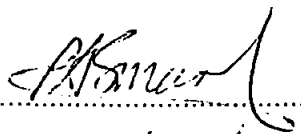
The resource intensive nature of the modelling phase of BPR was indicated and contextualised by a composite five stage methodology. Further research has challenged this methodological approach and indicated six fundamental issues which should be addressed by a BPR project. Two essential areas of BPR methodologies are identified as major research issues. These issues include the non-sequential orientation of methodological approaches and the need to systemically consider the six issues identified. Research on potential delivery mechanisms for a BPR methodology has focused on hypermedia environments which provide the transfer of expertise. A requirement of the design of these mechanisms needs to address models of human learning and the research which has been undertaken in the field of instructional design.

References

- Checkland P B, (1981), *Systems thinking, systems practice*, J Wiley and Sons, New York
- Checkland P, (1982), Systems concepts relevant to the problem of integrated production Systems in Wilson B (ed) *Efficiency of Manufacturing Systems*, NATO Series.
- Childe, S J, Maull, R S, Bennett, J, (1994), Frameworks for understanding business process re-engineering, *International Journal of Operations and Production Management*, Vol.14, No.12, 22-34.
- Childe S J, Weaver, A M, Maull, R S, Smart, P A, Bennett, J (1995), The application of generic process models in business process re-engineering, in Browne, J., O'Sullivan, D.(eds), *Re-engineering the Enterprise - Proceedings of the IFIP TC5/WG5.7 Working Conference on Re-engineering the Enterprise, Galway, Ireland.*, 110- 120.
- Childe S J, Smart, P A, (1995), The use of process modelling in benchmarking, in Rolstadas, A., (ed), *Benchmarking - Theory and Practice - Proceedings of the IFIP WG5.7 Workshop on Benchmarking - Theory and Practice, Trondheim, Norway, June 16-18 (1994)*, 190- 199.
- Churchman C W, (1971), *The design of inquiring systems*, Basic Books, NY
- Davenport T H, (1993), *Process Innovation*, Harvard Business School Press, USA
- Hammer M, (1990), Reengineering Work: Don't Automate, Obliterate, *Harvard Business Review*, July-August
- Hammer M, Champy J, (1993), *Re-engineering the corporation*, HarperCollins, New York
- Hannafin, M J, Phillips, T. L., (1987), 'Perspectives in the design of interactive video', *Journal of Research and Development in Education*, Vol 21, No. 1, Fall, 44 - 60
- Harrington J, (1984), *Understanding the manufacturing process*, Marcel Dekker Inc, New York
- Harrington H J, (1992), *Business Process Improvement*, McGraw-Hill
- Harvey D, (1994), *Re-engineering: The Critical Success Factors*, Business Intelligence Ltd, UK
- Knussen, C, Tanner, R G, Kibby, M R, (1991), An approach to the evaluation of hypermedia, *Computers and Education*, 17, 1, 13 - 24.
- Maull, R S, Weaver, A M, Childe, S J, Smart, P A, Bennett, J., (1995a), Current issues in business process re-engineering, *International Journal of Operations and Production Management*, Vol.15, No.11, 37-52.
- Maull, R S, Childe, S J, Bennett, J, Weaver, A M, Smart, P A,(1995b), 'Different types of manufacturing processes and IDEF₀ models describing standard business processes', working paper WP/GR/J95010-6, University of Plymouth, August.
- Pagoda Associates Ltd, (1993), *Pagoda Process Management Report*, London
- Parnaby J, (1993), *Business Process Systems Engineering*, Lucas Industries plc, November
- Porter M E, (1985), *Competitive Advantage: Creating and Sustaining Superior Performance*, The Free Press, NY
- Skinner, C, Pearson, J R W, (1993), *Business Process Re-engineering in the UK Financial Services Industry*, Highams Systems Services Group Ltd.
- Veasey P W, (1994), Managing a programme of business re-engineering projects in a diversified business, *Long Range Planning*, Vol 27 No 5
- Weaver A, Maull R, Childe S, Bennett J., (1994), A Soft Systems Perspective of Business Process Re-engineering, *International Conference on Systems Engineering*, Coventry, Sept. 11-13.

Copyright Statement

This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that its copyright rests with its author and that no quotation from the thesis and no information derived from it may be published without the author's prior written consent.

Signed.....

Date..... 31 / 10 / 96