Robert James Howlett
Editor

Innovation through Knowledge Transfer

SMART INNOVATION, SYSTEMS AND TECHNOLOGIES 5

Springer

Robert James Howlett (Ed.)

Innovation through Knowledge Transfer

Smart Innovation, Systems and Technologies 5

Editors-in-Chief

Prof. Robert James Howlett
KES International
PO Box 2115
Shoreham-by-sea
BN43 9AF
UK
E-mail: rjhowlett@kesinternational.org

Prof. Lakhmi C. Jain
School of Electrical and Information Engineering
University of South Australia
Adelaide, Mawson Lakes Campus
South Australia SA 5095
Australia
E-mail: Lakhmi.jain@unisa.edu.au

Further volumes of this series can be found on our homepage: springer.com

Vol. 1. Toyoaki Nishida, Lakhmi C. Jain, and Colette Faucher (Eds.)
Modeling Machine Emotions for Realizing Intelligence, 2010
ISBN 978-3-642-12603-1

Vol. 2. George A. Tsihrintzis, Maria Virvou, and Lakhmi C. Jain (Eds.)
Multimedia Services in Intelligent Environments –
Software Development Challenges and Solutions, 2010
ISBN 978-3-642-13354-1

Vol. 3. George A. Tsihrintzis and Lakhmi C. Jain (Eds.)
Multimedia Services in Intelligent Environments –
Integrated Systems, 2010
ISBN 978-3-642-13395-4

Vol. 4. Gloria Phillips-Wren, Lakhmi C. Jain,
Kazumi Nakamatsu, and Robert J. Howlett (Eds.)
Advances in Intelligent Decision Technologies –
Proceedings of the Second KES International
Symposium IDT 2010, 2010
ISBN 978-3-642-14615-2

Vol. 5. Robert James Howlett (Ed.)
Innovation through Knowledge Transfer, 2010
ISBN 978-3-642-14593-3

Robert James Howlett (Ed.)

Innovation through Knowledge Transfer

Springer

Dr. Robert James Howlett
KES International
PO Box 2115
Shoreham by Sea
West Sussex BN43 9AF
UK
E-mail: rjhowlett@kesinternational.org

ISBN 978-3-642-14593-3 e-ISBN 978-3-642-14594-0

DOI 10.1007/978-3-642-14594-0

Smart Innovation, Systems and Technologies ISSN 2190-3018

Library of Congress Control Number: 2010930912

Typesetting: Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Foreword

KES International (KES) is a worldwide organisation that provides a professional community and association for researchers, originally in the discipline of Knowledge Based and Intelligent Engineering Systems, but now extending into other related areas. Through this, KES provides its members with opportunities for publication and beneficial interaction.

The focus of KES is research and technology transfer in the area of Intelligent Systems, i.e. computer-based software systems that operate in a manner analogous to the human brain, in order to perform advanced tasks. Recently KES has started to extend its area of interest to encompass the contribution that intelligent systems can make to sustainability and renewable energy, and also the knowledge transfer, innovation and enterprise agenda.

Involving several thousand researchers, managers and engineers drawn from universities and companies world-wide, KES is in an excellent position to facilitate international research co-operation and generate synergy in the area of artificial intelligence applied to real-world 'Smart' systems and the underlying related theory.

The KES annual conference covers a broad spectrum of intelligent systems topics and attracts several hundred delegates from a range of countries round the world. KES also organises symposia on specific technical topics, for example, Agent and Multi Agent Systems, Intelligent Decision Technologies, Intelligent Interactive Multimedia Systems and Services, Sustainability in Energy and Buildings and Innovations through Knowledge Transfer. KES is responsible for two peer-reviewed journals, the International Journal of Knowledge based and Intelligent Engineering Systems, and Intelligent Decision Technologies: an International Journal.

KES supports a number of book series in partnership with major scientific publishers.

Published by Springer, 'Smart Innovative Systems and Technologies' is the KES flagship book series. The aim of the series is to make available a platform for the publication of books (in both hard copy and electronic form) on all aspects of single and multi-disciplinary research involving smart innovative systems and technologies, in order to make the latest results available in a readily-accessible form.

The series covers systems that employ knowledge and intelligence in a broad sense. Its focus is systems having embedded knowledge and intelligence, which may be applied to the solution of world industrial, economic and environmental problems and the knowledge-transfer methodologies employed to make this happen effectively. The combination of intelligent systems tools and a broad range of applications introduces a need for a synergy of scientific and technological disciplines.

Examples of applicable areas to be covered by the series include intelligent decision support, smart robotics and mechatronics, knowledge engineering, intelligent multi-media, intelligent product design, intelligent medical systems, smart industrial products, smart alternative energy systems, and underpinning areas such as smart systems theory and practice, knowledge transfer, innovation and enterprise.

The series includes conference proceedings, edited collections, monographs, handbooks, reference books, and other relevant types of book in areas of science and technology where smart systems and technologies can offer innovative solutions.

High quality is an essential feature for all book proposals accepted for the series. It is expected that editors of all accepted volumes take responsibility for ensuring that contributions are subjected to an appropriate level of reviewing process and adhere to KES quality principles.

Professor Robert J. Howlett
Executive Chair, KES International
Visiting Professor, Enterprise: Bournemouth University
United Kingdom

Preface

For much of their history universities in the United Kingdom were concerned almost entirely with teaching and research. Over the past few decades, however, a third mission has been established focussing on university enterprise activities, links with business and more recently still, collaboration with the community. This third stream of activity is often generically referred to as 'knowledge transfer'.

There are remarkable success stories to be told of the benefits of knowledge transfer, but few opportunities to publicise them. The first International Conference on 'Innovation through Knowledge Transfer: Research with Impact', InnovationKT'09, held at Hampton Court, Kingston upon Thames, UK on Wednesday 2nd December 2009, provided a rare and welcome opportunity to share some of the successes of knowledge transfer. This volume, representing the proceedings of the conference, containing full papers based on selected articles presented at the conference.

Organised jointly by the KES International knowledge transfer organisation and Kingston University in partnership with the Institute of Knowledge Transfer, the conference attracted over 150 delegates from academia, government and business.

The Honorary Chairs were Iain Gray, Chief Executive of the Technology Strategy Board, and Sir Brian Fender, Chair and President of the Institute of Knowledge Transfer.

Sir Brian Fender gave an invited talk entitled "Innovation and Knowledge Transfer: The Role of the Individual" and a paper based on the talk is included in this volume. A second invited talk was given by Dr Claire Graves, Head of Knowledge Transfer and Economic Impact at Research Councils UK (RCUK) entitled "The RCUK's Knowledge Transfer and Economic Impact Strategy". In addition, the conference featured 42 oral presentations grouped into seven conference sessions. Although representation at the conference was mainly from the UK, authors and delegates also came from a range of countries including France, Germany, Finland, and Brazil, providing a valuable international element.

This volume contains 35 full papers, based on selected conference presentations, grouped into seven sections. Section 1, 'Key Knowledge Transfer Perspectives', contains three papers providing an introduction to knowledge transfer and an overview of some of the important issues relating to the subject.

Section 2 on 'Knowledge Transfer Case Studies' contains 13 papers describing practical examples of knowledge transfer projects involving a range of higher-education partners and companies. Section 3 on 'Innovative Knowledge Transfer

Techniques' contains four papers describing some new and original techniques for achieving effective knowledge transfer.

There are six papers in Section 4 covering 'Strategic and Organisational Approaches to Knowledge Transfer'. Knowledge transfer in the Arts and the Community has achieved ever increasing importance over the last decade. Section 5 with this name contains two papers providing examples of this.

Section 6 contains four papers on 'Knowledge Transfer Methodology and Practice'. Knowledge transfer is closely related to innovation. Section 7 contains three papers specifically looking at innovation aspects of knowledge transfer.

The first InnovationKT conference was unique in gathering such a tremendous range of knowledge transfer experience and expertise. The event was certainly a success. A second conference is being organised in 2010 and there are plans to continue the momentum with a conference series. There is also interest in launching a peer-reviewed journal on the subject.

The organisers of the conference would like to thank the many people who contributed to its success. We are grateful to the keynote speakers, for the insight and inspiration their talks provided and we thank them. We thank the International Programme Committee for advising on the conference and reviewing the papers, thus ensuring quality and relevance.

We are extremely grateful to Kingston University which provided substantial sponsorship for the conference and the Local Arrangements Chair, Charlene Edwards, Head of Knowledge Transfer at Kingston University, and her team, who did a wonderful job of administering the event.

Finally we thanks the authors and delegates, without whom the conference would not have taken place.

Robert James Howlett
General Chair, InnovationKT'09

Conference Organisation

Honorary Co-chairs

Sir Brian Fender CMG MInstKT
Chairman and President of the Institute of Knowledge Transfer

and

Mr. Iain Gray
Chief Executive of the Technology Strategy Board

General Conference Chair

Professor Robert James Howlett
Executive Chair, KES International &
Bournemouth University, UK

Local Arrangements Chair

Ms. Charlene Edwards
Head of Knowledge Transfer, Kingston University, UK

Innovation through Knowledge Transfer: Research with Impact 2009 was organised by KES International (http://www.kesinternational.org) in partnership with Kingston University (http://www.kingston.ac.uk) and the Institute of Knowledge Transfer (http://www.ikt.org.uk).

The InnovationKT Proceedings are published in
Smart Innovation, Systems and Technologies: A KES-Springer Book Series

Series Editors

Prof. Robert James Howlett, Bournemouth University, UK
and
Prof. Lakhmi C. Jain, University of South Australia, Australia

International Programme Committee

Raffaele de Amicis	Centre for Advanced Computer Graphics Technologies - GRAPHITECH, Italy
Ian Bradshaw	Liverpool John Moores University, UK
David Brown	Portsmouth University, UK
Kate Butler	University of Reading, UK
Francisco Cipolla-Ficarra	Int. Ass. of Interactive Communciation / Latin Ass. of Human-Computer Interaction
Paul Donachy	Queens University Belfast, Northern Ireland, UK
Charlene Edwards	Kingston University, London, UK
Brian Fender	Institute of Knowledge Transfer, UK
Philip Graham	Institute of Knowledge Transfer, UK
Iain Gray	Technology Strategy Board, UK
Christos Grecos	University of the West of Scotland, UK
Sue Gunn	City University, UK
Ileana Hamburg	University of Applied Sciences Gelsenkirchen, Germany
Owen Hanson	University of Middlesex, UK
Russ Hepworth-Sawyer	Institute of Knowledge Transfer, UK
Emma Hewitt	University of Plymouth, UK
Tzung-Pei Hong	National University of Kaohsiung, Taiwan
Robert James Howlett	Bournemouth University / KES International, UK
James B. Johnstone	University of the West of Scotland, UK
Zne-Jung Lee	Huafan University, Taiwan
Debbie Lock	Kingston University, London, UK
Ignac Lovrek	University of Zagreb, Croatia
Suzanne Martin	University of Ulster Jordanstown, Northern Ireland, UK
Maik Maurer	Technische Universitaet Muenchen, Germany
Maurice Mulvenna	University of Ulster, Northern Ireland, UK
Rajesh Reghunadhan	Bharathiar University, India
Christophe Roche	Universite de Savoie, France
Liana Stanescu	University of Craiova, Romania
Vladimir Stantchev	Berlin Institute of Technology, Germany
Francis Tuffy	NPL, UK
Val Wooff	Durham University, UK
Cecilia Zanni-Merk	INSA-Strasbourg, France

Invited Speakers

Sir Brian Fender CMG MInstKT
Chairman and President of the Institute of Knowledge Transfer

Innovation and Knowledge Transfer; The Role of the Individual

Abstract

Innovation and Knowledge Transfer are now major policy areas for governments around the world. However despite the importance of these activities in a highly competitive world, freshly enhanced by major global challenges and economic crises, there is often a lack of clarity around the processes involved. This will be explored by reference to historically important inventions and to the emergence of innovation and knowledge transfer as areas of legitimate study. Although the role of individuals in 'Eureka' style discoveries is usually understood we need to ask how important is the role of an individual in the now big scale conversion of R&D into benefits for the economy and society? Taking account of changes in business and universities the talk will point to the increasingly vital role for Knowledge Transfer practitioners as individuals as well as how some new expectations are supported by the Institute of Knowledge Transfer.

Biography

Sir Brian Fender has been an active member of the Knowledge Transfer industry for most of his career having been Chief Executive of the Higher Education Funding Council for England from 1995-2001 and Chairman of BTG plc from 2003-2008.

Prior to that he was Vice-Chancellor of Keele University, Associate Director and Director of the Institut Laue-Langevin in Grenoble, France and Chairman of the Science Board of the UK's Science and Engineering Research Council. He is a graduate and Fellow of Imperial College. He is a Director of Higher Aims Ltd, a private consultancy involved in higher education and research management. Sir

Brian is a Fellow of the Institute of Physics and the Royal Society of Chemistry and a Companion of the Chartered Management Institute. He has honorary degrees or fellowships from 12 universities and colleges.

Dr. Claire Graves

Head of Knowledge Transfer and Economic Impact, RCUK

The RCUK's Knowledge Transfer and Economic Impact Strategy

Biography

Dr Claire Graves, Head of Knowledge Transfer and Economic Impact, Research Councils UK Strategy Unit, has worked for the Research Councils since 2000, and in the Research Councils UK (RCUK) Strategy Unit for the last two years, previously covering research policy. Since June she has had responsibility for the coordination and strategic delivery of the cross-Council Economic Impact agenda.

Contents

Perspectives on Knowledge Transfer

Knowledge Transfer Case Studies

Strategic and Organisational Approaches to Knowledge Transfer

Knowledge Transfer in the Arts and Community

Knowledge Transfer between UK Universities and Business

Robert James Howlett

Executive Chair, KES International, 145-157 St John Street, London, EC1V 4PY, UK
Visiting Professor for Enterprise, Bournemouth University, UK
e-mail: rjhowlett@kesinternational.org

Abstract. In this paper, knowledge transfer between universities and business in the UK is examined at a number of different levels. The term 'knowledge transfer' has different meanings in different contexts and so the meaning of the term from a UK perspective is discussed. As UK knowledge transfer is usually part of the innovation agenda, the meaning of 'innovation' is also considered. A number of different activities, considered to be part of the third mission agenda, are often thought of as being capable of achieving knowledge transfer. The most common of these are described and the potential of each for actually achieving knowledge transfer is discussed. The UK government flagship knowledge transfer scheme, Knowledge Transfer Partnerships, is widely acknowledged to a very effective knowledge transfer paradigm. The Knowledge Transfer Partnerships methodology is described, and two case studies of projects that have been successfully carried out using this paradigm are presented. These case studies illustrate the point that while knowledge transfer was effectively achieved during the partnerships, innovation was also facilitated as a vital part in the process. The factors encouraging and supporting innovation during a knowledge transfer partnership are discussed. The conclusion is drawn that the knowledge transfer partnerships methodology forms a framework exhibiting a number of features that makes it more likely that innovation will arise, and that it is this combination of knowledge transfer and innovation that makes the scheme so effective and successful.

1 Introduction and Definitions

For a considerable time in their history UK universities were concerned only with teaching and research. More recently, however, a third mission has been established focussing on university enterprise activities, links with business and more recently still, collaboration with the community. This third mission activity has led to a third stream of funding (in addition to teaching and research funding) which universities, with government encouragement, increasingly wish to exploit. The 2009 Annual Innovation Report records that UK universities' external income was over £2.8 billion in 2007/08 (latest available figures) more than doubling in real terms since 2001 and increasing by 6.5% on the previous year [1].

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 1–14.
springerlink.com

Various government initiatives relating to the university-business interface can be identified dating back several decades, for example the Teaching Company Scheme which originated in the mid-70s. Just in the past five years there have been several significant reviews emphasising the importance and potential of this new area of activity, of which the following are examples. The Leitch review of the UKs long term skills [2] needs concluded that "*…higher level skills are key drivers of innovation, entrepreneurship, management, leadership and research and development critical to a high skills, high performance economy increasingly in demand from high performance, global employers...*". One of the recommendations of the Warry report on the impact of the Research Councils [3] was to "*Expand incentives for researchers to participate in knowledge transfer*". The Government accepted the recommendations of the Sainsbury review of science and innovation [4] and announced actions especially relevant to knowledge transfer, for example "*Improved knowledge transfer between the research base and business through an improved Higher Education Innovation Fund, building up support for business-facing universities, and a doubling of Knowledge Transfer Partnerships to boost research-business links.*" The latest Annual Innovation Report [1] contains a recommendation to "*.... broaden knowledge exchange between the research base and business into the arts and humanities and service sectors such as the creative industries*."

Knowledge may originate from a range of sources, including independent research centres outside the higher education sector. Hence, the UK Government Department of Business, Innovation and Skills (BIS, the ultimate successor to the Department of Trade and Industry) states on its web site that *"Within a modern, knowledge driven economy, knowledge transfer is about transferring good ideas, research results and skills between universities, other research organisations, business and the wider community to enable innovative new products and services to be developed"* [5].

While the concept of knowledge transfer originated in the desire to commercialise the outcomes of scientific research, the benefits of disseminating the outcomes of non-scientific research into the wider community more recently became appreciated. Hence, the RCUK web site describes knowledge transfer in the following terms *"Knowledge transfer describes how knowledge and ideas move between the knowledge source to the potential users of that knowledge. The Research Councils encourage knowledge transfer by supporting schemes and activities to transfer good ideas, research results and skills between, for example, universities and other research organisations, business, the third sector, public sector and/or the wider community."* [6]

The definition by the Economic and Social Research Council (ESRC) reinforces the idea that knowledge transfer has to have a commercial objective, as stated by its web site [7] *"Knowledge exchange is about exchanging good ideas, research results, experiences and skills between universities, other research organisations, business, Government, the third sector and the wider community to enable innovative new products, services and policies to be developed."*

UK university-business knowledge transfer has for some time been considered to be part of the innovation agenda, where the aim is to inject new ideas into companies to improve their competitiveness and profitability. An important implicit aim is that it should be orientated towards a useful outcome in business terms. Specifically, knowledge transfer should lead to innovation, which should in turn result in economic improvements reflecting on the bottom line profitability of a business.

Joseph Schumpeter defined innovation as 'ideas applied successfully in practice' and identified as areas where innovation can be applied the introduction of new goods, new methods of production, the opening of new markets, the conquest of new sources of supply and the carrying out of a new organization of any industry[8].

Hence, knowledge transfer can be applied to businesses to improve their bottom line profitability through, for example, the following types of innovation:-

- Devising new products or services, or improvements to existing products or services
- Improving manufacturing processes, including cost reduction and waste elimination
- Embedding new organisational concepts such as continuous improvement or mass customistaion
- Enhancing marketing strategies, enabling new markets to be challenged or finding better ways to challenge existing markets
- Interacting with customers better through e-commerce, web and internet systems

There is increasing interest in applying knowledge transfer to the social economy including organisations such as cooperatives, non-governmental organisations, charities, voluntary or non-profit bodies, or the community. In the case of a non-profit organisation, the aim of applying knowledge transfer to improve profitability may not be valid, although producing an increased surplus to be fed back into the organisation may be. In such a case, alternative objectives need to be specified such as:-

An increased level of activity achieved with the same level of staff and resources

- The same level of activity carried out with fewer staff and resources
- The ability to carry out activities that would not have been possible before
- An increased level of financial surplus to be reinvested into the organisation

Although the broad principles of knowledge transfer are well understood and stated in the context of UK university-business and community interaction, the term knowledge transfer is also used and understood in other sectors, where it is interpreted differently. Knowledge transfer has a place in aspects of business management. In this context knowledge transfer is considered to be the practical problem of transferring knowledge from one part of an organisation to another area of the organisation, or indeed to another organisation altogether. This area topic is well covered in the literature (for example [9] and [10]); however, it is outside the scope of this paper.

The preceding discussion leads the following definition of knowledge transfer in the context of UK universities, business and the community: Knowledge transfer is the application of the knowledge of a university or non-university research centre into a business or community organisation, leading to innovation that improves its ability to operate in terms of improved profit or efficiency.

This rest of this paper focusses on knowledge transfer between UK universities and businesses.

2 Paradigms for Knowledge Transfer

There are a number of activities that are often grouped under the 'third-mission' heading. The most common of these are described in this section, and the extent to which each is likely to be an effective mechanism for university-business knowledge transfer is discussed.

2.1 Knowledge Transfer Partnerships

Supported by Government funding through the Technology Strategy Board (TSB), Knowledge Transfer Partnerships (KTP), and its predecessor the Teaching Company Scheme (TCS), has been in operation for about 35 years. It has been described as one of the most effective knowledge transfer mechanisms and is the UK Government's flagship knowledge transfer initiative [11].

A KTP project of the classic model involves a university or other research centre, a company or community organisation, and a KTP Associate. The Associate is a graduate that is employed to work in the client company or organisation on the project.

This three-way partnership undertakes a project of strategic importance to the company or community organisation. The project must have as a target outcome a defined improvement in the profitability of a company or improvement in the way a community organisation is able to function. The project must also deliver benefits for the Associate and the university.

While the classic model KTP project undertakes strategic projects of about one to three years, a recently introduced shorter KTP (sKTP) is now available for projects with a tactical outcome, having a duration of up to 40 weeks, and an Associate who may have a lower level qualification.

During the 2008-9 year there were 964 Partnerships and 1021 Associate places in the KTP portfolio with an aspiration to increase numbers further [12]. Over the years and decades it has been in operation, the KTP model has gained an enviable reputation for delivering high-quality innovation to UK companies through its three-way knowledge-transfer interactions between firms, universities and skilled graduates.

Two successful KTP projects are described here [13, 14, 15]. KTP will be considered in more detail in Section 3 of this paper.

2.2 Conference and Journal Publications

Publishing of journal and conference papers is a required output of university research. It represents an established method of disseminating research results and circulating them among the rest of the research community. However, the effectiveness of publication as a method of knowledge transfer must be debatable. Knowledge is '*broadcast*', but it may not reach those who need it. Papers usually contain a limited level of detail, often for reasons linked to intellectual property rights, and may be too superficial to make effective exploitation of the knowledge possible. In addition, companies, particularly SMEs, may have difficulty accessing academic published papers for licensing reasons, they may be considered too theoretical and not sufficiently business-relevant.

While no statistics are to hand, it is likely that many more readers access conference papers than attend the conferences, and that most readers of journal papers do so without having an individual copy of the journal. Increasingly conference and journal papers are held online. Often, particularly in the case of science and technology papers, this is by Thomson ISI's Web of Science, Elsevier's Science Direct or Springer's Springerlink. Searches can be performed for papers of interest using a web search engine that indexes academic publications, for example Google Scholar [16], Scirius, CiteSeeeX and IEEEXplore. Google Scholar will only display index entries for which users are provided with a freely available abstract of the paper [17], and it gives primacy to full text versions.

While many publishers make abstracts of articles freely available on the web, full text versions are often only available through a paid subscription. Universities often have subscriptions covering multiple publishers so that staff and students are able to access the full text versions of papers. Private research centres and companies large enough to have dedicated research departments many also have similar subscriptions. However, small companies are unlikely to find it cost effective to subscribe, and they may lack experience of finding information in this way.

Hence, while publication can be effective at achieving knowledge transfer between universities, there must be doubts about how effective it currently is in achieving knowledge transfer to companies, particularly SMEs. Future trends towards open content, and the growing tendency for authors to make preprint or postprint copies of papers openly accessible on the internet, may have a beneficial effect on this position.

2.3 Spin-Outs and Spin-Ins

Spin-out companies, joint company ventures and licensing agreements are often included under the third mission umbrella and in some parts of the world (for example the USA, following the Bayh-Dole act) can be considered predominant modes of university-business interaction [18, 19].

A spin-out company is often formed with the objective of generating revenue, or another useful outcome, from a university's intellectual property rights (IPR) through converting it into a commercial product or service and then marketing it.

In some cases a spin-out arises because a university identifies knowledge it wishes to exploit so as to generate a revenue stream for itself. However, the motivation often comes from the academic and income generation is not always the driver. The wish to give something back is growing in some areas as is demonstrated by UnLtd recently having been launched to fund HEI social enterprises [20].

Fazackerley et al in their paper 'Innovation and Industry' notes that the UK could claim to be a world leader in the area of university spin-outs, but only ranks number 11 in the 2009 INSEAD Global Innovation Index on university-business research collaboration. They conclude that there must be more to university-business interaction than spinning out companies [21]. As the desire to commercialise IPR comes from its originator, a spin-out represents a university-led approach rather than one based on customer need.

This is *'technology push'* rather than *'market pull'*. As such, it does not represent a flexible approach capable of meeting customer requirements in a range of areas. A spin-out can achieve knowledge exploitation and generate revenue for a university, and knowledge transfer occurs between the university and the spin-out. However, it is not clear how a spin-out can achieve knowledge transfer and innovation outside this. Also, while a spin-out may generate a product of use to other companies, equally the product may form competition to existing offerings and the spin-out may become a rival to existing companies.

Formation of a spin-out company can require a significant level of investment that represents a risk to the university. A joint venture company in the form of a spin-in, or an arrangement where the technology is licensed to a company, are alternatives. A spin-in, where a company works with the university to develop their product or service, can in some circumstances provide a more rapid return on investment than licensing. Flexible arrangements are possible where the university agrees to offer support in exchange for a shareholding or a share of profits or both. A spin-in can also potentially achieve a better fit customer needs, as it is focussed towards the customers' requirements.

2.4 Contract Research and Consultancy

A university may undertake to carry out on a paid basis research and development, product design, investigation of some problem, etc, for a client that does not possess the knowledge to do it themselves. Although knowledge will be transferred into the product through this mechanism it does not necessarily become embedded into the client company. Thus, contract research may form a ‘quick fix’ that deals with a specific problem, but it often does not give the client company the expertise to deal with similar problems in future themselves.

To overcome this need, some form of training or work-based learning can be linked to the contract research to embed the knowledge into the client company. Alternatively, the knowledge provider may form a continuing revenue stream from providing solutions for the client company.

2.5 Short Courses and Training

Properly structured training can be an effective form of knowledge transfer. However, a problem with short courses can be that course participants may feel they understand the material during the course, but find they are unable to apply it when they are back in the company. Embedding of the knowledge is important for the company to gain maximum benefit. This can be achieved by proper post-course support. Alternatively, structured in the right way, a programme of work-based learning can be an effective means of knowledge transfer.

2.6 Knowledge Transfer Networks

Funded by UK Government through the Technology Strategy Board, Knowledge Transfer Networks (KTNs) are an effective indirect mechanism for supporting knowledge transfer. KTNs raise awareness of specific areas of technology, they facilitate and support research and they are a good mechanism for communication, networking and loosely sharing knowledge. To this extent they achieve informal knowledge transfer. KTNs can also form a means of putting those in need in need of knowledge with potential suppliers of it.

2.7 New Knowledge Transfer Mechanisms

The development of the internet and related technologies has made available new techniques with the potential for use in knowledge transfer. Although not fully developed yet, there are interesting possibilities for innovative knowledge transfer schemes based on a combination of distance and work-based learning, with the embedding of the knowledge secured through the knowledge agent or associate being an employee of the knowledge client company. This could be a very-cost effective knowledge transfer mechanism where the knowledge client company is an SME, but remains to be explored further.

3 Knowledge Transfer Partnerships

Having considered a number of possible methods of achieving innovation through knowledge transfer in Section 2, the classic Knowledge Transfer Partnerships model, having a well-established track record in knowledge transfer, is discussed in more depth. In this Section, more detail is provided about the structure and operation of a KTP project. Section 4 provides two case study descriptions of KTP projects and in each case an attempt is made to discern the components of knowledge transfer and innovation that took place. Finally, in Section 5, KTP is considered as a framework for facilitating innovation through knowledge transfer.

Each classic model Knowledge Transfer Partnership involves three participants, a UK company, a Knowledge-Base Partner (usually a university), and a graduate, called a KTP Associate. The company must have a need for a demanding project of a strategic nature. This must be something that will lead to real business benefits in terms of increased turnover and profit, or safeguarded market-share. The project must also be something that the company could not do for itself, without the help of the Knowledge-Base Partner.

Although the Knowledge Base Partner is most frequently a university, it can be a Research Technology Organisation (RTO) or a Public Sector Research Establishment (PSRE) However, few eligible non-university research centres (compared to the number of universities participating) have taken advantage of the opportunity to act as the knowledge base partner in a KTP project.

The Knowledge-Base Partner must have a high level of skills and expertise to contribute to the project. This is provided through an Academic Supervisor who has technical skills in the area of the project, and who also mentors the KTP Associate. To be suitable for KTP, the Associate must be able to benefit from the associate development programme that is offered, which means they must usually have gained their most recent qualification in the recent past. They must have a qualification appropriate to the project, for example, a first or upper second class honours degree for a classic KTP.

During the operation of the KTP, the Associate works in the company carrying out the project. The Associate works under the direction of the Academic Supervisor, and a member of the company staff, the Industrial Supervisor, who acts as the Associate's line manager. The Academic Supervisor visits the company on a regular basis, and commits to contributing half a day a week of their time to the project over the life of the partnership. The Associate works under the company's conditions of service, although they have a contract with the university partner, who is given responsibility for managing the grant. Although there is no compulsion on the company to offer a permanent position, and no compulsion on the Associate to stay, for many Associates KTP can offer a route to continuing employment with the company.

Each Knowledge Transfer Partnership carries attractive funding from the TSB or one of a number of other sponsors to the scheme. If the company is a Small to Medium Enterprise (SME), approximately within the European Union definition, i.e. has fewer than 250 employees and turnover and company values within certain limits, a classic model Knowledge Transfer Partnership provides funding of 66% of the project budget, and the company pays the remaining 33%. If the company does not qualify as an SME the project attracts about 50% funding, and the company contribution is 50%.

In order to obtain a Knowledge Transfer Partnership and the grant income it includes, a credible and financially beneficial business case must be presented in the proposal document. At the end of the project the benefits arising from the project are assessed by independent reviewers.

The business benefits actually obtained vary widely because of the wide range of types of projects, companies and business sectors but are held to make a significant contribution to the UK economy [12].

4 Case Studies

In this section, case studies based on two completed KTP projects are presented as examples of the way in which the scheme can achieve innovation through knowledge transfer.

4.1 Case Study A

The Company: Company A was an innovative SME (Small to Medium Enterprise) located in the South East of England but trading internationally. The business of the Company was the design and manufacture of high-power solid-state lasers for industrial applications in the materials processing and micro-electronics manufacturing markets.

The Target Requirement: The Company wished to further improve the reliability of its products by implementing a pro-active condition monitoring strategy to achieve the very early signs of problems before the problem actually occurred. By this means unplanned down-time could be avoided, saving the cost or unanticipated failure. While the Company had world-class skills in the design and development of its laser products, it lacked specialist knowledge of condition monitoring, although the Managing Director had gained some exposure to the subject in his career.

The University: The University of Brighton Centre for Smart Systems had considerable experience of condition monitoring and the application of artificially intelligent software systems to the prediction of failure.

The Project: The Centre for Smart Systems provided two staff to act as academic supervisors in a two-year KTP project with the Company to develop the require condition monitoring strategy and system. An honours graduate in Electronic Engineering was recruited as the KTP Associate to undertake the project.

The Outcome: Analysis of the laser system design was carried out leading to a system model and a diagnostic matrix mapping possible faults to observable symptoms. Two approaches to symptom monitoring were evaluated. Firstly, a classical statistical technique (the Control Chart or Shewhart Chart) was combined with a rule-based system, and implemented in custom software that could be embedded in the product. This enabled continuous condition monitoring of the system. Secondly, an artificial intelligence technique known as a 'neural network' was evaluated as a possible method of monitoring the output of the laser in such a way that potential failure could be anticipated. The techniques made available to the Company through the project satisfied the Target Requirement. Embedding of the knowledge was achieved through the Associate carrying out a programme of training of company staff in the new techniques and updating company documentation.

The Knowledge Transfer: Knowledge of condition monitoring and intelligent systems was conveyed to the Associate from the Academic Supervisor. It was also gained by the Associate through his own research, guided by the Supervisor, and his attendance at an MSc module on the subject at the university. However, in addition to knowledge transfer, there was the origination of new knowledge. The combination of conventional condition monitoring techniques and intelligent systems technology that arose out of the project was not available before the project. The project achieved both the transfer of existing knowledge and also innovation, in the form of the origination of new knowledge about condition monitoring using a synthesis of existing techniques. It was the innovation that produced the solution, but the innovation could not have taken place without the knowledge transfer.

4.2 Case Study B

The Company: Company B was an SME located in Kent. It was a provider of integrated financial and accounting software, networking and IT training to companies in a number of industry sectors across the UK.

The Target Requirement: The Company wished to to implement internet-based customer support and problem-solving facilities to provide 24 hour/day support to customers. This would provide a better service for customers, and also reduce the amount of time service representatives were spending on telephone support calls. While the Company had the ability to develop bespoke modules for the software it sold, it lacked knowledge of internet software development and other specialist techniques that would be necessary to satisfy the requirement.

The University: The University of Brighton Centre for Smart Systems possessed experience of software engineering, internet-based software and smart diagnostic systems.

The Project: The Centre for Smart Systems provided two staff to act as academic supervisors in a two-year KTP project with the Company to develop the support system. An honours graduate in software engineering was recruited as the KTP Associate to undertake the project.

The Outcome: The Partnership succeeded in achieving improved product information, self-help diagnostic facilities, customer information about accounts and improved call tracking, all of which provided enhanced scope and availability of customer service delivery, potentially leading to increased sales. The target requirement was fully satisfied. In addition the company gained benefits not originally foreseen in the form of increased visibility in web search engine rankings, leading to additional revenue from resulting sales.

The Knowledge Transfer: When the project was proposed it was envisaged that what would be developed was a piece of software known as an expert system. This is a known technique that encapsulates the knowledge of experts, in this case the service representatives, and uses it to diagnose problems. A documented problem with expert systems is that after the development of the system, users of the system can find it difficult to add new problems and diagnoses as they become known, and the system falls into disuse. It became clear that the Company's service representatives were likely to find it difficult to maintain a conventional expert system, and that such a solution would not be a long term success. An innovative solution was developed based on frequently asked questions (FAQs), accessed through plain text queries and linked to a knowledge base. A simple method of updating the knowledge base was provided, convenient for use by Company staff and integrated into their day to day activities. Knowledge transfer in the area of smart diagnostic systems and software engineering took place between the Academic Supervisor and the Associate, who also gained additional knowledge of these subjects through personal study. However, the software solution that was devised did not arise just out of this knowledge transfer. A conventional expert system would not have been suitable, and therefore a new kind of system was devised that drew on expert systems but also other areas. The system that formed the solution was a synthesis of conventional and new techniques that arose out of both knowledge transfer and innovation.

5 KTP as a Framework for Innovation

The term 'knowledge transfer' can lead to the idea that knowledge will be transferred (or copied) from the university in the person of the Academic Supervisor to the company through the intervening 'pipeline' of the Associate. In fact, the Academic Supervisor provides specialist knowledge about the application domain. However, it is unlikely that they will have the solution to the company's problem ready for immediate implementation. It is more likely that the Associate will need to work under the guidance of both the Academic Supervisor and the company to devise a solution to the problem. The Academic Supervisor will provide knowledge about how to solve the problem, but will not directly provide the solution.

For example, say a company wishes to design a new product. The Academic Supervisor will be able to guide the Associate through a process which involves investigating customers' requirements, evaluating options, implementing the design, etc. However, the Academic is unlikely to have the new design in their head ready for implementation. If another company wishes to produce a drug to cure a particular ailment, the Academic Supervisor is unlikely to have the cure already in their head. They will not be able to directly transfer the knowledge that compound X cures ailment Y into the company. However, they may be able to transfer knowledge about approaches to the problem, and how to go about finding a drug effective in the cure of the ailment.

Thus, it can be argued that the knowledge that is transferred is knowledge about how to find a solution or approach a problem, rather than the solution itself. The Associate is mentored, cultured and educated in how to solve problems, perform an investigation, carry out a design etc., rather than being a solution being transferred for implementation in the company. The Academic Supervisor, therefore, needs to be more than just a technical guru.

During its lifetime a successful KTP project creates an environment where innovation is encouraged, facilitated and supported. Innovation occurs and is supported and cultured through a number of factors that arise out of the KTP structure.

The KTP project structure creates an atmosphere where the Associate is expected to "make something happen" i.e. they are expected to produce a solution to a problem. The Associate is expected to take ownership of the project and ensure its success (given the support of the other parties). The Associate is 'ring-fenced' from the day-to-day activities of the company. Although the Associate inevitably makes a contribution to the wider activities of the business, it is intended that their focus is on the KTP project. Their prime responsibility is ensuring the success of the project. These factors act as an incentive and a spur to success.

Regular visits by the Supervisor (weekly, fortnightly or late in the programme, monthly) act as regular spurs and triggers points for progress by the Associate. The supervision meetings involve both the Academic and Industrial Supervisors, the Associate, and sometimes company management. As well as monitoring progress, each meeting can act as an ideas workshop, where ways of overcoming obstacles to progress are discussed, options for progress are evaluated and the best way forward selected. These meetings can make a significant contribution to achieving incremental innovation. Formal four-monthly meetings of the Local Management Committee (LMC) attended by the KTP Advisor (essentially the government representative who monitors the project), senior company management and supervisors act as another, higher level, prompt to progress.

Thus, there are a number of influences at work in a KTP project, the project requirements of the company, the availability of knowledge through the Academic Supervisor, the company and the Associate's study, the time structure imposed by the visits of the Academic Supervisor, LMC meetings and the fixed length nature of the project, the expectations of progress, and the keenness and enthusiasm of the Associate. While innovation is not guaranteed, the supportive and fertile environment created by this combination of factors makes it more likely that an innovative outcome will occur that satisfies the project requirements and achieves benefits for the three partners.

6 Conclusion

The topic of this paper, knowledge transfer between universities and business, is not widely covered in the literature and its mechanisms and processes are not well described. This paper is an attempt to introduce the subject and to begin to analyse some of the processes at work in successful projects delivered under the KTP model.

Having considered several paradigms that could potentially lead to university-business knowledge transfer it is concluded that the most effective of these is likely to be KTP. While KTP leads to knowledge transfer, sometimes it is not obvious what knowledge is transferred during the course of the project. In some projects specialist technical or business knowledge is transferred. However, it would appear that it is often broad knowledge about the subject domain together with knowledge of how to approach and undertake the project that is transferred.

In addition, knowledge is gained by the Associate from within the company and from their own study.

What does the Associate do with this knowledge, gained from disparate sources? The Associate uses it to synthesise new knowledge, in the form of the solution to the problem, the design of the new product, the new improved method of manufacturing, etc. The important function of a successful KTP project team is to create an environment where this new knowledge can be created, grown and applied to achieving the aim of the project. The creation and growth of this new knowledge is innovation and the strength of KTP is that it cultures and supports this innovation.

Hence it is concluded that a successful KTP project involves both knowledge transfer and the use of the knowledge that has been transferred to facilitate innovation. The supportive framework that cultures innovation is an essential component in the success of the project.

References

[1] 2009 Annual Innovation Report. Department for Business, Innovation and Skills (2010), `http://www.bis.gov.uk/Policies/innovation/annual-innovation-report` (accessed March 1, 2010)

[2] Leitch Review of Skills: Prosperity for all in the global economy - world class skills. HM treasury (2006), `http://www.hm-treasury.gov.uk/d/leitch_finalreport051206.pdf` (accessed March 1, 2010)

[3] Warry Report: Increasing the economic impact of the research councils (2006), `http://www.vitae.ac.uk/cms/files/DTI-Warry-Report-July-2006.pdf.3072` (accessed March 1, 2010)

[4] Sainsbury Review of Science and Innovation. HM Treasury (2007), `http://www.hm-treasury.gov.uk/d/sainsbury_review051007.pdf` (accessed March 1, 2010)

[5] Department for Business, Innovation and Skills web site, `http://www.dius.gov.uk/science/knowledge_transfer` (accessed November 26, 2009)

[6] Research Council UK web site, `http://www.rcuk.ac.uk/innovation/ktportal/default.htm` (accessed November 22, 2009)

[7] Economic and Social Research Council web site, `http://www.esrc.ac.uk/ESRCInfoCentre/Support/knowledge_transfer/index.aspx` (accessed November 22, 2009)

[8] Schumpeter, J.: The Theory of Economic Development. Harvard University Press, Cambridge (1934)

[9] Argote, L., Ingram, P.: Knowledge Transfer: A Basis for Competitive Advantage in Firms. Organisation Behaviour and Human Decision Processes 82(1), 150–169 (2000)

[10] Sunaoshi, Y., Kotabe, M., Murray, J.Y.: How technology transfer really occurs on the factory floor: a case of a major Japanese automotive die manufacturer in the United States. Journal or World Business 40, 57–70

[11] KTP Online Web Site, Technology Strategy Board, http://www.ktponline.org.uk/ (accessed March 1, 2010)
[12] Knowledge Transfer Partnerships Annual Report 2008/9, Technology Strategy Board, http://www.ktponline.org.uk/libraryMaterial/KTPAnnualReport0809.pdf (accessed March 1, 2010)
[13] Howlett, R.J., Dawe, G.P., Nowell, T.: Condition Monitoring Capability Developed Through a Knowledge Transfer Partnership between a Small Company and a University. In: Khosla, R., Howlett, R.J., Jain, L.C. (eds.) KES 2005. LNCS (LNAI), vol. 3683, pp. 1173–1179. Springer, Heidelberg (2005)
[14] Howlett, R.J., Dawe, G., Walters, S.D.: Intelligent Condition Monitoring of High-Power Laser Systems. Journal of System Science (2008)
[15] Wood, S., Howlett, R.J.: A Web-Based Customer Support Knowledge Base System. In: Lovrek, I., Howlett, R.J., Jain, L.C. (eds.) KES 2008, Part I. LNCS (LNAI), vol. 5177, pp. 349–361. Springer, Heidelberg (2008)
[16] Google Scholar, http://scholar.google.com (accessed March 1, 2010)
[17] Support for Publishers, http://scholar.google.com/intl/en/scholar/publishers.html (accessed March 1, 2010)
[18] Siegel, D.S., Waldmand, D.A., Atwater, L.E., Link, A.N.: Commercial knowledge transfers from universities to firms: improving the effectiveness of university-industry collaboration. Journal of High Technology Management Research 14, 111–133 (2003)
[19] Siegel, D.S., Waldmand, D.A., Atwater, L.E., Link, A.N.: Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. Journal of Engineering Technology Management 21, 115–142 (2004)
[20] UnLtd web site, http://www.unltd.org.uk (accessed March 25, 2010)
[21] Fazackerley, A., Smith, M., Massey, A.: Innovation and Industry: The Role of Universities. Policy Exchange Research Note, http://www.policyexchange.org.uk/images/publications/pdfs/Innovation_and_Industry.pdf (accessed November 31, 2009)
[22] Knowledge Transfer Networks, http://www.ktnetworks.co.uk/ (accessed March 1, 2010)

Innovation and Knowledge Transfer the Role of the Individual

Brian Fender

Institute of Knowledge Transfer

Abstract. Innovation and knowledge transfer will be the keywords in the coming decade. There are several reasons for this; we will have to be innovative to combat the major challenges of climate change and the different aspects of security from terrorism and rogue states to pandemics. Poverty in some parts of the world remains a challenge and there is a need to create sustainable jobs as global competition intensifies. This paper dissects the key elements of innovation and knowledge transfer and emphasises the role that individuals play in both breakthrough technologies and innovation through continuous improvement. Trends in open innovation are included and the responses that are required of management and business models are outlined. The increased role of Universities in knowledge transfer is discussed as part of increased professionalism in higher education. Finally the role of the Institute of Knowledge Transfer, the recognised professional body for knowledge transfer professionals, is referred to as well as the requirements of a new profession.

1 Components of Innovation and Knowledge Transfer

Innovation is a heavily overused word and there is a risk that it is thought of as a panacea. To retain clarity about the elements of innovation it is helpful to break down the process of innovation into five component parts. This recognises that innovation is built on a knowledge base that it requires certain specific skills, and that there is always a problem to address. Centrality of the problem Centrality of a problem is obvious in conventional R&D fields, but it is equally applicable to an entrepreneur, where a market need or perceived market needs provides the necessary focus. But marshalling the necessary knowledge and skills to tackle a problem is not in itself sufficient for innovation. There has to be a creative contribution before there can be benefits to either to the economy or society.

The impact of innovation varies very widely. We are all clear that some innovations, radically change the way we live. These 'eureka' events occur when the creativity released in tackling a problem has consequences that go well beyond the initial problem. Such transformational effects, nearly always begin with one or two individuals, but will often dependent on others for realisation. Consider Fleming's discovery of penicillin, and the vital contributions of Florey and Chain with biochemistry skills. Watson and Crick's proposal for the structure of DNA needed the experimental data of Wilkins and Franklin. At the time, no one could have

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 15–25.
springerlink.com

seen the enormous commercial use of lasers. However both Gould and Townes separately demonstrated great imagination in their pursuit of the production of coherent light sources [1].

How does knowledge transfer relate to innovation? It is now necessary to recognise that although creativity is an essential step in innovation it does not itself necessarily lead to a benefit. What the innovative process delivers is an outcome which may be advancement in research, or a proposal for a new drug or the development of a prototype etc. The role of knowledge transfer is to take the outcomes of an innovative process and bring them to commercial or societal value. This is achieved by matching market needs or potential market needs to the innovative outcome and helping to outline a developmental pathway. Alternatively, knowledge transfer involves taking successfully exploited innovation in one field and applying it to another.

2 Research into Innovation

Describing the components of innovation and knowledge transfer is clearly not sufficient for an understanding of these very important processes. More research is certainly needed. Current research is conveniently grouped into areas where the focus is on economic, geographic, process and social dimensions [2]. Economic interests focus on economic growth competitiveness and employment. Geographic research has an interest in local or regional factors such as the clustering of funds in a similar industry; national policies and the effects of globalisation. Research into the processes of innovation is concerned with how innovation is nurtured in organisational structures and the measurement of impact. The social dimension, of growing importance, involves the balance of explicit and tacit knowledge in the diffusion of ideas. It is also concerned with the creation of networks and the competencies necessary for practitioners. The relationship between these research areas and the components of innovation and knowledge transfer are given in figure 1 below.

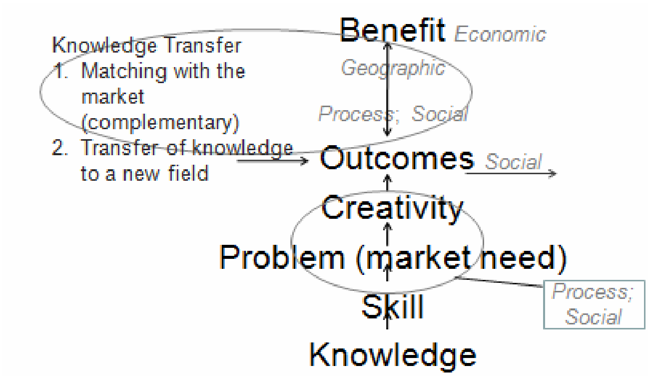


Fig. 1 Components of Innovation and Knowledge Transfer with related research areas

3 Innovation and Improvement; Endoscopy as a Case History [3]

The major innovations referred to earlier are by their nature unpredictable. More typical are developments, which combine mixture of innovation and improvement. The development of the endoscope, see figure 2, is an excellent illustration of evolution of a powerful medical tool.

The early stages of endoscopy in the 1930s involved a semi-flexible gastroscope a very primitive and probably painful way of viewing our insides. This became a much more promising instrument with the advent of fibre optics in the early 1950s. The early use of optic fibre bundles in endoscopy however was far

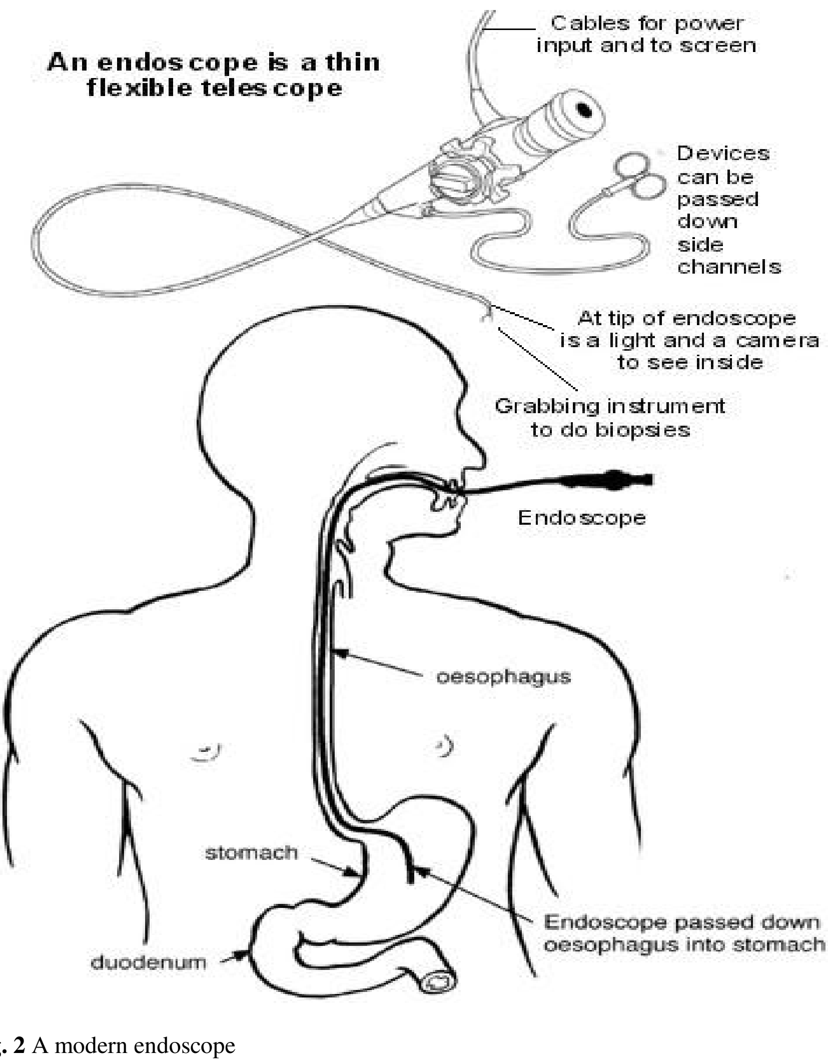


Fig. 2 A modern endoscope

from satisfactory. Not only were the fibre bundles difficult to form, the glass was imperfect, and the image degraded by crosstalk between fibres. Major improvements arose from the group of Peters, Curtis, and Hirshowitz at the Ann Arbour campus of the University of Michigan.

According to reports, Hirshowitz was attracted to Ann Arbour by the high reputation of the University of Michigan, and a stimulating research environment. Creating the right environment for innovation remains a very important consideration in 2010.

The critical innovation in making the endoscope a much more attractive tool came from Curtis, an undergraduate at the time, who created a composite glass fibre which enhanced the image and attracted development work from manufacturers. The improved instrument brought video guided endoscopy, and then in the early 80s, the introduction of the CDD chip to replace the multi-fibre bundle simplified the manufacture and improved the visual resolution. With the collaboration between gynaecologist and manufacturers endoscopy evolved from simply a viewing device into a guide for minimally intrusive surgery laparoscopy. By the 1990s, gallstone surgery, which had previously been a major surgical operation with traditional techniques have become largely a laparoscopic procedure.

What are the general lessons are to be learnt from the endoscopic case history? One is that continuous improvement over a sustained period of time can more than match a single major innovation. Secondly that important benefit arises from the collaboration between the innovators (discoverers) and users (market). The ideal, of course, is for the technical development and market development to occur as closely as possible together. A third lesson comes from the observation that the time taken to adopt the new techniques into general surgical practice was longer than might have been expected on purely technical grounds. The new surgical opportunities provided by laparoscopy were resisted by older surgeons; a new generation of surgeons needed to be trained for the technique to become generally applicable. It must be expected that for innovation to be effective social adaptation, education and training must occur.

4 The Battle for Hearts and Minds

The focus of innovation today is often on new systems, rather than simply finding new products. We need a concerted effort from many innovators and knowledge transfer practitioners to make a dent in some of the biggest challenges. One approach is illustrated by the US National Academy of Engineering [4]. In 2007, a group of academics, businessmen, and opinion makers were asked to draw up a list of the biggest challenges facing engineering in this century. The list of topics is intriguing, reflecting as it does the broadening horizons of engineering. The debate about these 14 grand challenges was initiated by asking for views on priorities and from more than 25,000 responses a priority order was drawn up which ran from make solar energy economical through reverse engineer the brain, advance health economic informatics, to secure cyberspace. Subsequently, each of these topics has been discussed, the opportunities identified and possible approaches debated. Considerable effort has been put into making the results of these discussions, widely available. What motivates the Academy of Engineering? It is not in itself a grant giving body, so this is not an exercise to assess the scope for investment. In fact, progress in tackling the challenges is only part of the Academy's purpose. Of major importance is that the debate around the challenges draws attention to educators of the skills in engineering and related disciplines that will be necessary to foster the necessary intensity of innovation. The complexity of the challenges and the requirements for an input of disciplines other than engineering focuses attention on the creativity also necessary. The Academy is in effect, marketing engineering. It is attempting to maximise the concentrations of skill and creativity around its perception of the major problems that fall within the scope of engineering. It is an appeal to individuals, to teach or to study or to be engaged in creative activity through the nature of the intellectual challenges.

5 Open Innovation

As well as attempts to draw talent into the innovation arena there have been attempts to better conceptualise innovation. The most important contribution is that championed by Henry Chesbrough and colleagues using the term 'Open Innovation'. Open Innovation is defined as: 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the market for external use of innovation, respectively. Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology'[5].

In UK, we can see this approach exemplified in two ways by GlaxoSmithKline. The first is exemplified by the creation a centre of excellence for drug discovery. The goal is described succinctly as 'supporting the development of the best from anywhere. The focus is on developing alliances with world-class research and development organisation that like us are open to innovation. Not just in science but in all aspects of the discovery process.' The second approach aimed at providing relatively easy access to developing technologies was announced in the latter part of 2009. It involves the creation of a world class Science Park, near GSK Stevenage research base. The campus supported by UK government, academia and the Wellcome trust, as well as the Company aims to pioneer a new operating model of open innovation which should strengthen and grow the UK bioscience sector. It is hoped that the new campus will compete with similar Parks in Boston, California and North Carolina in the United States.

The aim of open innovation is not just to provide easier access to early stage discoveries. It is to harness what James Surowiecki has famously described as the wisdom of crowds. Here, the key element is to access to an individual's knowledge and experience not just that of an organisation. On the multinational scale this is best illustrated by IBM in a series of so-called Jams. The first in 2001 aimed through consultation, to capture best practices on 10 urgent IBM issues by consulting staff suppliers and customers. IBM captured 268,000 views from 6000 inputs. By 2006 the innovation Jam was broadened both in ambition, and scale. The aim of the consultation was how to combine IBM's new technologies with real-world insights to create new market opportunities. 150,000 people contributed from 104 countries and 67 companies. As a result 10 new businesses were created with the seed investment of $100 million. In 2008 [6] vision was bolder; to advance IBM's vision of the ‘enterprise of the future’ and to draw on the brains of individuals from many more companies. In practice, staff from 1000 companies, plus the IBM cohort engaged in a conversation over a 90 hour period around the themes of ‘Built for Change; Customers as Partners; Globally Integrated, and The Planet and its People.’

In addition, IBM conducts worldwide debates around themes which are likely to have a significant IBM interest for the Company. The aims, reminiscent of the American Academy of Engineering’s, grand challenges, are designed to draw attention to the skills and creativity needs around general themes of global interest. This allows also allows the Company to engage with individuals in emerging economies. In one recent debate on Security and Society, the contributors from the Far East outnumbered those from the US. By associating IBM with topics such as the security of 3 billion mobile phones the risks associated with the highly extended food supply chain of for example the hamburger, the high global volumes of identity theft and car theft it is pointing to technology’s role (and that of IBM) , in innovation and knowledge transfer that impinges on everyday lives.

It is not just large companies exercising open innovation. Use of search engines reveals a plethora of portals, and individual sites, with relatively small-scale offers of problems and solutions. This is open innovation as an Exchange and Mart and very much the home for individual contributors.

6 The Digital Phenomenon

We referred earlier to the role of individuals in breakthrough advances such as penicillin, lasers, and the structure of DNA. Equally striking is the role of individuals in leading models of social communication. The digital revolution associated with Facebook is an outstanding example. Created by Mark Zuckerbrook and friends at Harvard Facebook exemplifies not only in youthful entrepreneurship but also, trust in the company's users to sustain innovation. The Facebook platform was opened up in 2007 and within months there were 5000 applications and the company was worth $15 billion. There are other now well-known examples such as YouTube (Chad Hurley et al) and Napster (Shawn Fanning). The appetite of the younger generation for Web 2.0 was such that it was plausible for John Palfrey and Urs Gasser as late as 2008 [7] to describe a born digital generation (digital natives b>1980) which was at home with the web in a manner greatly more intense than older generations. Jack Dorsey the creator of Twitter changed all that. Users of the Twitter site grew to 10 million in less than two years, and across a wide age range. We are all digital natives now.

A consequence of that is that mass collaboration using digital technologies is transforming all aspects of the knowledge society even more rapidly than was envisaged. It is still possible however to construct a hierarchy based on digital impact. Knowledge and information-based services, obviously lead, closely followed by the creative and cultural sectors, in particular media advertising software and in entertainment, film and television. Not far behind are communications and publishing. The impact on less obviously affected areas such education, health and public administration is growing constantly as it is in the retail trade, financial and business services.

7 Innovation and Management

One area relatively untouched by innovation and knowledge transfer is management. Some would agree with Gary Hamel that modern management has reached the limits of improvement. If management is to change what are the challenges? Inspired by the National Academy of Engineering's grand engineering challenges, a group of scholars and business leaders met in 2008 and subsequently laid out a roadmap for reinventing management which contains 25 challenges. Some of those are given below in Fig 3:

Challenges to Business Models and **Management**

'Modern management has reached the limits of improvement'

- **Ensure that the work of management serves a higher purpose**
- **Eliminate the pathologies of formal hierarchies**
- Reduce fear and increase trust
- Redefine the work of leadership
- **De-structure and disaggregate the organisation**
- Reinvent strategy making as an emergent process
- Share the work of setting direction
- **Create a democracy of information**
- Create internal markets for ideas, talent and resources
- Empower the renegades and disarm the reactionaries
- Expand and exploit diversity
- Develop holistic performance measures
- **Further unleash human imagination**

Fig. 3 Challenges to Management taken from reference [8]; the authors emphasis in bold

What is immediately evident is the emphasis on an enhanced role for individuals reflecting the imperative for organisations in future to make the most imaginative use of internal and external networks.

8 Open Innovation and Business Models

As well as management structures, business models will need to change to account for more open and systematic innovation [9]. The business environment will increasingly be affected by emerging product markets, emerging ecosystem and changes in established industries that are driven by open innovation. We are likely to see increased differentiation between niche products and services, and those which contain a convergence of different elements. The mobile phone is a classic example of the latter containing, phone, music player, camera and aspect of a PC. Medicines tailored to meet patients with particular genetic requirements would be an example of the former. Particularly exciting examples of the potential for convergence is a virtual power station were elements of production, such as the conventional power station, nuclear power station, windmills and solar power are linked with the consumers varied and variable demands .

9 The Innovation Environment and the UK in 2010

The importance of innovation and knowledge transfer demands an environment which encourages both activities. It is important to recognise the government has an influential role on both the discoverers and developers of new ideas, and the market. That triple helix of university -- industry -- government has been very well described by Henry Etzkowitz [10]. There is a case also for the consideration of facilitators such as patent experts or intermediate, e.g. biotechnology, companies as important separate players.

The government's biggest contribution to the innovation and knowledge transfer environment has been the increase in government investment in the Science Budget from £1.3 billion in 1997 to £3.7 billion now. Together with additional funding through the higher education funding councils research in the UK has ever been better funded although some way short of the overall target for R&D spend of 2.5%. But the increased investment plans with higher expectations of delivery by higher education of economic and social benefits. This burden of expectation is likely to be severely tested by whatever government comes into place after the next election.

One structural change that should be permanent is the creation of the Technology Strategy Board. There is a need for a national body to ‘connect, and catalyse through strategic debate and competitive funding’. The development of application areas such as environmental sustainability, energy generation and supply, healthcare and the creative industries alongside technology areas such as high-value manufacturing and nanotechnology is a welcome step and one more likely to be fruitful than complicating the funding of the highest quality of research in universities with difficult assessments of economic and social impact.

10 The Contribution of Universities

Universities, play an absolutely crucial role in the stimulation of discovery and the early-stage developments in innovation and knowledge transfer. They have responded very well to this is challenge. In this context, universities are very different institutions than a decade ago. The adoption of knowledge transfer of the third mission for universities, sits well with the developments or potential developments in teaching and research. Figure 4 encapsulates some of the essential elements in today's universities, but emphasises the interrelationship between the three missions.

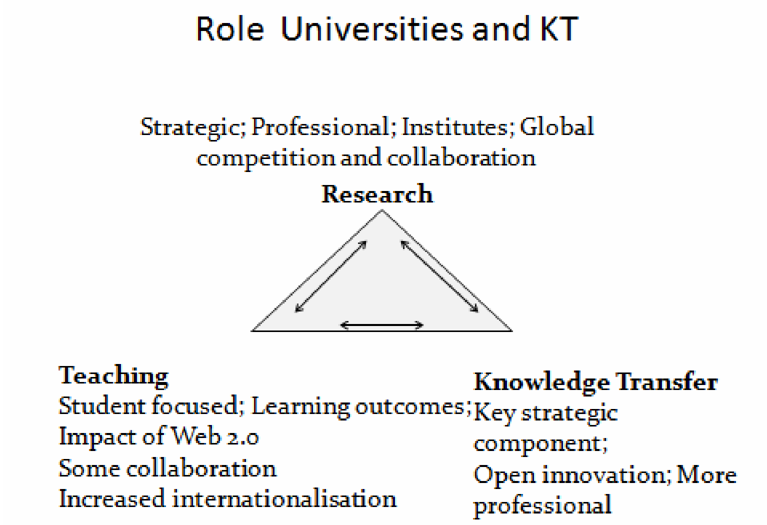


Fig. 4 Universities now or in the near future

The perception of the nature of the contribution to innovation has also changed in the last 10 years. The original emphasis was very much focused on the commercialisation of intellectual property. Now there is recognition that tacit knowledge plays at least as important a role as explicit knowledge. This can be readily seen from the income universities derive from knowledge transfer activities [11] where the income associated with intellectual property is much lower is much lower than that for partnership and collaborative research or consultancy. The highly successful Knowledge Transfer Partnership scheme illustrates this point very well. The KTP associates play a key role in managing and implementing strategic development projects. But they also broker, tacit knowledge exchange between universities and business. Continuing professional development is also an important contributor to knowledge transfer as a source of ideas and personal connections as well as education and training.

11 The Institute of Knowledge Transfer

The realisation that successful knowledge transfer depends critically on the quality of personal interactions has led to the growth of practitioners specialising in knowledge transfer and a discussion of the individual competencies that the necessary for success. There have been discussions in both Europe and the UK about competency frameworks. A personal list of the key elements is given in figure 5.

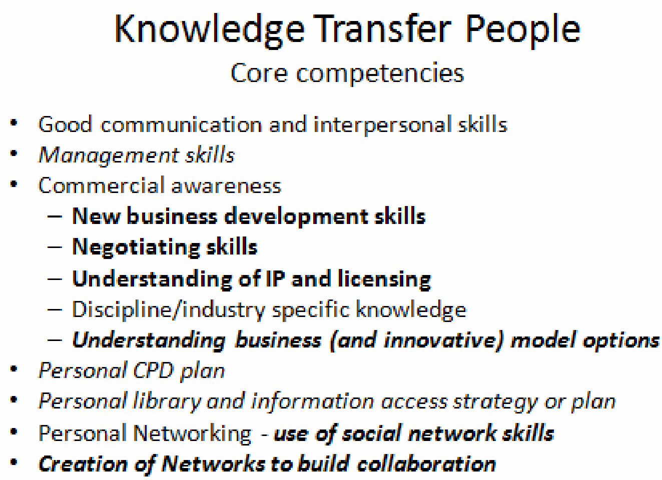


Fig. 5 Important personal competences in KT cf key elements of the education programme for Certified Trans-national TT professionals EC report 2007; authors additions (italics) and emphasis (bold); see also reference [12]

The distinctive list of competencies associated with knowledge transfer heralds the birth of a new profession. This has been recognised by the creation of the Institute of Knowledge Transfer [13]. IKT is an individual membership body based on professional standards. These standards are set by a peer review of workplace learning and CPD as well as an assessment of the articulation of skills and competencies required for professional success. The Institute provides a range of services which are outlined in Figure 6:

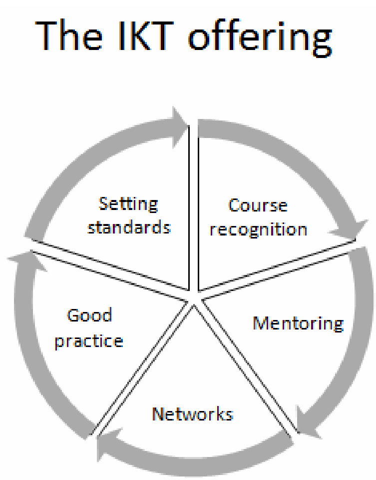


Fig. 6 IKT services

A key feature of the Institute is a is that it defines knowledge transfer broadly, which enables members to network with and between more focused KT organisation it is open to members from the private and public sectors and its membership is indeed drawn from business/industry research/discovery, as well as intermediate companies and facilitators. Figure 6 illustrates the services offered and is an explicit recognition that our future innovation and knowledge transfer depends on individual initiative.

12 Conclusions

We are at the birth of a new profession which encompasses both innovation and knowledge transfer. The emergence of a profession promotes reflection on the boundaries of the new professional activity although these boundaries will be subject to constant review and revision. The discipline of a profession also requires us not only to look at its scope, but to research the underpinning processes. We need to know more about the environments that stimulate innovation and the mechanisms which lead to successful knowledge transfer. Because of the complexities of interactions involved in innovation and knowledge transfer, both within and outside organisations, this paper argues that the profession will develop most quickly if it recognises the powerful role of individuals. Open innovation implicitly recognises this dimension and it is now for managements to make the changes in management structures, culture and business models that are necessary for success.

References

1. See for example Horvitz ‘Eureka’ Wiley 2002 (2002)
2. Fagerberg, Mowery, Nelson: Oxford Handbook of Innovation, OUP 2005 (2005)
3. Rosenberg: Studies on Science and the Innovation Process, p. 235. World Scientific, Singapore (2010)
4. http://www.engineeringchallenges.org/
5. Open Innovation Edited by Chesbrough, Wim Vanhaverbeke & West OUP 2006 (2006)
6. http://www.ibm.co/ibm/jam
7. Palfrey, Gasser: Born Digital. Basic Books, New York (2008)
8. Hamel Harvard Business Review, p. 91 (February 2009)
9. See Jens Christensen presentation in the Centre for Open Innovation, Haas Business School, University of California, Berkeley (November 2009)
10. Etzkowitz: The Triple Helix. Routledge, NY (2008)
11. HEFCE Publication 2009/23
12. AURIL CPD Framework, http://www.auril.org.uk
13. http://www.ikt.org.uk

UK Higher Education Perspectives of Knowledge Transfer

Deborah Lock

Executive Director, Enterprise
Kingston University, United Kingdom

Abstract. This paper considers the route of the current knowledge transfer (KT) paradigm by examining some of the key policy documents on the development of university business engagement since 1925. It provides examples of successful mechanisms for effective knowledge transfer, and comments on some of the challenges facing Higher Education Institutions seeking to expand and further develop their knowledge transfer portfolios at a time of political uncertainty and economic austerity. The paper also seeks to show that the Higher Education sector is responding to change by developing its ability to communicate, share, exchange existing and create new knowledge through a wide variety of mechanisms resulting in a KT platform that supports and encourages open innovation and greater business interaction.

1 Historical Context

Although it can be argued that the UK Higher Education (H.E.) sector has recently experienced a major paradigm shift through the establishment of a permanent third stream mission,[1] the relationship between 'the University' and 'Business' has been the subject of debate for many years. For example, in Baillie's (1925) 'Industry and the University' address to the Association for Education in Industry and Commerce he presented the case for greater trust and co-operation between the two parties, without a culture of suspicion and jealousy, as a means to solving industrial challenges whether this be through graduates, that is, *'scientifically trained young men'* or through the application of science in the workplace [1]. The concentration and focus on universities as playing a pivotal role in providing and shaping a skilled workforce was a key driver behind much post-war H.E. planning which then led to a rapid expansion of student numbers. In essence post-war Britain *'needed educated manpower',* an educational system that could *'achieve*

[1] The term 'third stream' is used to reflect the policy which supports business, enterprise and community engagement that is, a third mission complimentary to teaching and research. Typically this includes research & business development, knowledge & technology, commercialisation, business creation and enterprise/entrepreneurship education.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 27–38.
springerlink.com

greater social and educational equality than existed before the war' and a mechanism that could do this without undermining academic and quality integrity [2].

By 1963 the Robbins Report added to the debate through identifying four aims and objectives for Higher Education, one of which included '*instruction in skills for employment.* [3] Two decades later, the 1987 White Paper Higher Education: Meeting the Challenge served to reaffirm the Government's commitment to universities and business working together in partnership to develop *'teaching… research and technology transfer…and foster positive attitudes towards enterprise'* [4]. Up until the 1980s, most of the discussions had been around the notion of universities and business working together to address employability skills and research agendas. The 1987 White paper was one of the first policy documents in UK higher education that used the term 'technology transfer' and thereby publically acknowledging the commercialisation potential of the research base.

In 1997, Sir Ron Dearing, was appointed by the Secretaries of State for Education and Employment, Wales, Scotland, and Northern Ireland to undertake a national review of higher education and to make recommendations on how *'the purposes, shape, structure, size and funding of higher education, including support for students, should develop to meet the needs of the United Kingdom over the next 20 years'* [5]. In many respects, this can be considered as the seminal work that laid the foundation of current knowledge exchange platforms since it marked a move away from an unplanned higher education system that to some extent had come about as a series of initiatives, to one with a coherent strategy that would enable higher education to be more responsive to the needs of business. In essence, Dearing's recommendations provided a business engagement blue print to which many universities still adhere:

Recommendation 38
We recommend to higher education institutions and their representative bodies that they examine, with representatives of industry, ways of giving firms, especially small and medium sized enterprises, easy and co-ordinated access to information about higher education services in their area.

Recommendation 39
We recommend:

- *to the Government that it considers establishing a modest fund to provide equity funding to institutions to support members of staff or students in taking forward business ideas developed in the institution, and to support the creation of incubator units;*
- *to higher education institutions that they establish more technology incubator units within or close to the institution, within which start-up companies can be fostered for a limited period until they are able to stand alone.*

Recommendation 40
We recommend to higher education institutions that they consider the scope for encouraging entrepreneurship through innovative approaches to programme design and through specialist postgraduate programmes.

Whilst Dearing argued the need for a flexible, accessible and end-user led approach to business engagement and identified a number of core services that universities could provide to business to encourage knowledge transfer, Lambert's 2003 Review of Business and University Collaboration focused on the barriers within the U2B[2] system that limited efficient and effective knowledge exchange. Amongst his recommendations were the creation of a range of model legal agreements setting out approaches to '*IP ownership, management and exploitation rights including, but not limited to, ownership of the IP by the university with non-exclusive licensing or exclusive licensing to industry*' and on-going Government investment in a permanent and substantial third stream of funding to increase the flow of knowledge and ideas from the science base into business and the wider community [6]. The focus of Dearing and Lambert on the development of university knowledge transfer capability and capacity building was further complemented by the Sainsbury Review which placed all the key elements of KT, that is teaching & learning, research & development and enterprise, clearly within an ecosystem in which relationships and dependencies resulted in open innovation based on co-creation and mutually beneficial knowledge sharing.

> 'A country's innovation rate depends on inter-linked activities which include: industrial research; publicly funded basic research; user-driven research; knowledge transfer; institutions governing intellectual property and standards; supply of venture capital; education and training of scientists and engineers; innovation policies of government departments ; science and innovation policies of RDAs; and international scientific and technological collaboration.' [7]

The Review had a major impact on HEIs, Research Councils (RCs) and Regional Development Agencies (RDAs) and their perception of and engagement with knowledge transfer activities that underpin science and innovation. For example, the Technology Strategy Board (TSB) was redefined and given a leadership role to co-ordinate public sector technological innovation activity, and lever public sector resources and simplify access to funds for business. RCs were encouraged to develop KT awards (the links between the Research Councils and KT are continuing to strengthen in response to the emerging 'impact' agenda), and the Government funded Knowledge Transfer Partnership scheme was expanded. Meanwhile RDAs were encouraged to work closely with universities to take a leading role in embedding KTPs within local business communities[3].

2 The Emergence of the Third Stream Activities

In response to the Dearing recommendations in June 1999, the Department for Employment and Learning in Northern Ireland (DELNI) announced the Higher Education Reach-out to Business and the Community (HEROBC) programme (HEFCE Circular 99/40).[8] At this point, third stream knowledge transfer within

---

[2] U2B means University To Business.

[3] South East of England Development Agency (SEEDA) developed its own version of a mini-KTP called Business + in 2008.

universities began in earnest. Prior to this there had been several small scale attempts by Government to transform good research into good business and strengthen the links between H.E. enterprise and the economy (whether this be through academic or student entrepreneurialism) but mostly with limited success.

The establishment of University proof-of-concept seed funds such as the University Challenge (UC)[4] was aimed at accelerating the route to market for new and innovative technologies emerging from curiosity-driven research, either through increasing the number of licence deals and /or increasing the number of university spin-out companies. In contrast to this, the Science Enterprise Challenge (SEC) resulted in the establishment of twelve SEC centres with a softer remit of *'specialising in the teaching and practice of commercialisation and entrepreneurialism in the field of science and technology'* and thereby producing more entrepreneurial staff and graduates. Whilst the benefits of UC and SEC funding were primarily felt by research-led institutions that showed commercial potential, HEROBC provided an opportunity for a much wider range of HEIs to put in place the organistional infrastructure required to increase their capability to respond to the needs of business and thereby contribute more to economic growth.

Building on the success of HEROBC, the Higher Education Innovation Fund (HEIF) programme was introduced in 2001. Since then there has been a further three rounds, each call having a slightly different emphasis which reflected the Government's stance at the time. HEIF1 [9] concentrated on *developing knowledge transfer capability* across the sector [CAPABILITY], HEIF2 [10] saw the incorporation of UC, SEC and the Higher Education Active Community Fund activities under its umbrella and a focus on *developing wide ranging knowledge transfer* activity [CAPACITY], HEIF3 [11] saw the introduction of formula based funding linked to income generation, and focused on *strengthening existing links and consolidating activity* [CONSOLIDATION], and finally, HEIF4 [12], the current round, is witnessing the validation of the permanency of third stream work as the annual monitoring via the Higher Education Business & Community Interactions Survey (HEBCIS) is transferred to Higher Education Statistical Agency (HESA) and linked to traditional HE statutory returns.

There is little doubt that the originator of the KT paradigm has been the Government, informed by and responding to 'Business' to some degree and is strengthened by the belief that unlocking the knowledge that exists within HEIs and research organisations will:

1. Contribute to economic growth and the overall competitiveness of UK PLC[5] in a global market;
2. Improve the nation's health through the accelerated release of innovative medical technologies;
3. Enhance the overall quality of life through informed policy development and implementation;

---

[4] University Challenge consisted of £50M made up from contributions from the Wellcome Trust, the Gatsby Charitable Foundation, and HM Treasury.

[5] en.wiktionary.org/wiki/UK_plc defines UK PLC as meaning *'UK commercial community considered as a single organization; or the commercial interests of the United Kingdom considered as a whole'.*

4. Engender a greater appreciation of our cultural heritage and enhance creative output; and
5. Improve environmental management through the sustainable renewable energy innovations.

There is little doubt that the success of this latest move, to include a permanent stream of KT activity that would complement teaching, research and contribute to the social and economic wealth of the nation, is dependent upon the sector being able to harness, translate, and exploit the skills, knowledge and expertise which exists within its HEIs.

	Funding (£M)	Year
HEIF 4 (including final CKE fund of 8M for 2008-09)	404	2008-11
HEIF 3 (including CKEs)	238	2006-08
HEIF 2 (including Centres for Knowledge Exchange - CKE)	187	2004-06
Knowledge Transfer Capability Fund	9	2004-06
HEACF 2	10	2004-06
HEROBC transitional funding	10	2003-04
Higher Education Active Community Fund (HEACF) 1	27	2002-04
Higher Education Innovation Fund (HEIF) 1	78	2001-04
Business Fellows	1	2001-04
HEROBC 2	22	2000-04
Higher Education Reaches-Out to Business & the Community (HEROBC) 1	62	2000-03
Science Enterprise Challenge	25	1998-04
University Challenge	50	1998-04
Enterprise in Higher Education [EHE Initiative]	100	1987-89
Total funding for Business & Community Engagement [Enterprise] to date	1223	

Fig. 1 Funding programme

Source: Modified from HEFCE website

3 The Rhetoric of Knowledge Transfer

The notion of transferring knowledge from universities is not new: it is what underpins teaching and learning. Whilst much of the language and terminology used may appear new, in many respects the rhetoric is simply reflecting a new interpretation of an existing activity which seeks to recognise the importance of *knowledge translation* (that is, packaging it in such a way that it is easily accessible) and the mutual beneficial of efficient and effective *knowledge sharing*.

Whilst there are many definitions of knowledge transfer[6] such as Argote's [13] which sees knowledge transfer as *"the process through which one unit (e.g., group, department, or division) is affected by the experience of another*", the one agreed between the Research Councils UK (RCUK), Department for Innovation, Universities and Skills (DIUS, previously the Office of Science and Innovation, and now called the Department for Business, Innovation and Skills) and the Research Councils would resonate with most HEIs:

> "Knowledge Transfer encompasses the systems and processes by which knowledge, expertise and skilled people transfer between the research environment (universities, centres and institutes) and its user communities in industry, commerce, public and service sectors."

The breadth of HEI knowledge transfer activities is considerable, ranging from development and management of Science Parks, collaborative R&D initiatives, the provision of incubation space to enable company creation, support for regional inwards investment, consultancy services, equipment and facilities hire, and higher level skills development. The PACEC/CBR 2008 [14] survey of academics identified four core knowledge exchange mechanisms: people-based, community-based, problem-solving and commercialisation. In essence, the UK Higher Education Knowledge Transfer platform has all of the features that support and encourage open innovation and greater interaction between business. [15]

Having said this, the most successful *'knowledge transfer agent'* continues to be the graduate and the skills and knowledge s/he develops during the course of their studies which is subsequently transferred into society and the economy. In terms of specific initiatives, the Government sponsored Knowledge Transfer Partnership programme (KTP) stands out as being one of the most comprehensive since it encapsulates all three HE missions (teaching & learning, research and enterprise) under one umbrella in an accessible way for business that results in mutually beneficial knowledge creation and knowledge exchange. This tripartite relationship has three clear benefits: companies acquire new knowledge and expertise which has a tangible and real impact on their business; associates gain work experience along with personal, academic and career development opportunities; and academics have greater opportunities to develop business-informed research, teaching materials and papers.

According to Howell and PACAC [16, 17] the overall benefits of participating in KTP and KT in general include:

- Income generation opportunities;
- Enhanced teaching and learning through business-informed content which reflects higher level skills needs and by default improves graduate employability;

[6] Knowledge Transfer' is beginning to be superceded by the term 'knowledge exchange', although there are a range of additional associated terms in use e.g. knowledge exploitation, knowledge sharing.

- Research development between business and academia which can ultimately contribute to curiosity-driven or applied research or a combination of both;
- Raised individual and institutional profiles which can act as a catalyst for new collaborative opportunities, attract new investment and improve student and staff recruitment; and
- Publications since KTP projects frequently result in articles.

In addition, as demonstrated by the KT Impact Conference (December 2009)[7], there is new field of investigation emerging and an increasing body of research into multi-disciplinary knowledge transfer in general.

There is little doubt that universities have the expertise and skills to work with small-to-medium enterprises (SMEs) but there is evidence to suggest that SMEs may not have the financial or resource capacity to work with universities on collaborative initiatives especially those that require commitment over a long period of time [18]. One solution which is proving to be successful is the adoption of an *'accelerator route to KT'* since it enables a business to build a KT portfolio which matches their available resources.

The SHELL STEP programme enables SMEs to recruit undergraduates to work on specific projects for an eight week period between July and August and thereby '*introduce fresh ideas and new skills/technologies or processes into their businesses'* [19]. The cost to the business is approximately £250 per week. The KTP programme has a built-in escalator starting with a mini-KTP lasting between ten and forty weeks and leading up to a Classic KTP which can take up to three years to complete. The flexibility and acceptance that 'one size does not fit all' is the attraction and particularly important as the extent of the current recession begins to unfold.

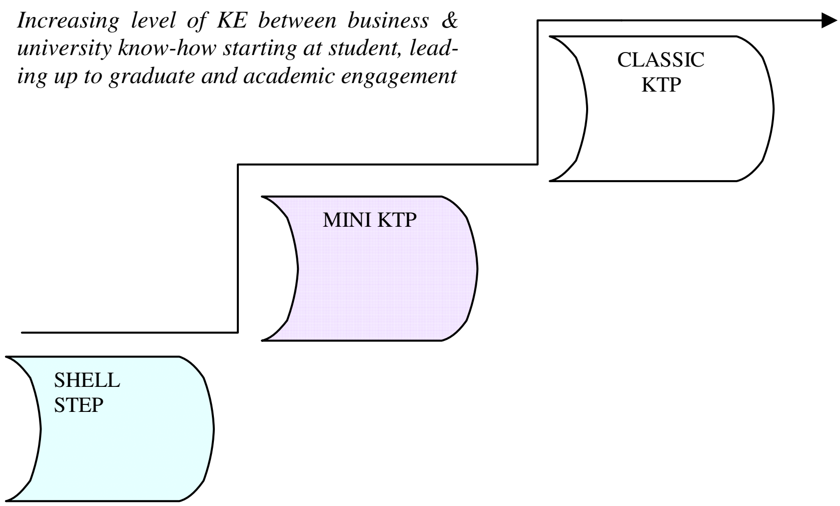


Fig. 2 Knowledge Transfer Escalator

[7] Innovation through Knowledge Transfer: Research with impact. 2nd December 2009, Hampton Court Palace.

Many knowledge transfer activities and projects will be able to demonstrate added-value relatively quickly. For example, a recent KTP at Kingston University which involved Hampton Court Palace has had the following short term impacts: increased visitor numbers and publicity for the Palace (economic impact); the development of new presentations and exhibitions for visitors, schools and colleges (social and cultural impact); and contribution of new knowledge to the field of Tudor history (impact on the scholarly nature of research in this area).

Inevitably, the diversity of the knowledge transfer portfolio means that KT activities will have a significant part to play in the impact agenda as the need to track, monitor and evidence impact beyond simple financial transactions will become increasingly important as universities seek to manage the new funding landscape.

4 Current Challenges Facing Knowledge Transfer

> "Not everything we start ends up fitting our businesses later on. Many of the ideas we work on here involve a paradigm shift in order to deliver value. So sometimes we must work particularly hard to find the 'architecture of revenues'…."

When John Seely Brown, Chief Scientist of the Xerox Corporation[20], made this it would have been hard to imagine that a decade later he could have been talking about the UK HE sector which has seen, and is continuing to see, a re-alignment and focusing of key funding to support activities in response to changing economic priorities. The need to diversify income and identify new revenue streams is becoming increasingly important as the sector embarks on a period of financial austerity.

4.1 Organisational Issues

The development and implementation of the third stream is inextricably linked to its public sector funding origins, and the documentation and literature charting Government and stakeholder engagement is plentiful. In sharp contrast to this, much of the research and literature surrounding third stream activities has focused on technology transfer and commercialisation; specifically, the impact this has on university policies such as Intellectual Property, Conflicts of Interests and spin-out formation (Tang, 2008) and gender issues in commercialisation [22,23,24]. Apart from the work of Slaughter & Rhoades [25] on academic capitalism in which it was recognised that HEIs will need to develop an *'extended managerial capacity'* to meet the challenges of stronger links with business, and the 2008 Wellings Report [26] that proposed a hub and spoke approach to support an enterprise eco-system, very little attention has been paid to the type of infrastructure required to underpin effective broad based knowledge transfer until recently when PACEC embarked on a series of investigations reviewing the knowledge exchange landscape; the results of which will be available in Spring 2010.

In the meantime, HEI senior management and Directors of third stream services are facing a number of critical organisational issues as a result of public sector funding reductions, reduced private sector R&D expenditure and political uncertainty. These are firstly, how to maintain and build on the momentum of the KT agenda at a time when core teaching & learning and research grants are under threat; secondly, how to retain the skills and competencies required to provide an efficient and effective knowledge transfer platform at a time when head-count reductions may be on the horizon and finally how to assess KT 'value for money', and identify where to disinvest and invest limited resources. These issues are exacerbated by the lack of certainty relating to the VAT/tax status of universities and the need to ensure that working closely with business does not undermine or put at risk the charitable status of many universities.

4.2 Academic Engagement

Whilst benefits of participating in KT activities are generally recognised and the need to reward and celebrate academic engagement is acknowledged [27,28, 29, 30], the overall landscape remains fragmented. The key factors influencing academic engagement in this arena include the lack of time due to existing workload commitments which prevent academics from participating. This is particularly pertinent if KT is not included in the academic workload model. Clearly an institution's capacity for KT outreach activities is critical to successful business engagement. To do outreach with employers, the academic community needs time set aside to make it happen. Similarly, whilst some HEIs provide promotion and career advancement linked to knowledge transfer and enterprise-related activities, others do not. KT will remain on the periphery until it is completely embedded within the academic career pathway, and in the meantime participation will remain to be seen as optional to some degree.

4.3 Business Engagement Issues

Over the last ten years the sector has adopted an innovative approach to KT, using a wide variety of mechanisms such as innovation vouchers[8], institutional business fellowship schemes[9] and targeted 'engagement' programmes such as

---

[8] http://www.lancs.ac.uk/researchenterprise/ivouchers.htm Innovation Vouchers are designed to help business owners, entrepreneurs, charities and social enterprises in NW England to purchase academic and/or technological expertise, in order to develop innovative solutions to their business problems, and to enhance their business performance.

[9] Http://www.kingston.ac.uk Kingston University operates a Business Fellowship Scheme which provides funding to faculties to either second someone from business to the University or vice versa to work on specific KT projects.

Profitnet[10]. All of these approaches have one thing in common – the aim to accelerate mutually beneficial knowledge exchange. Despite this, there remain a number of barriers to effective business engagement that need to be addressed if the sector is going to maximize its KT potential. Whilst there have been significant steps in publicising and promoting university expertise, there needs to be more. Full economic costing (FEC) continues to be problematic to most SMEs engaging with universities on collaborative projects because they cannot relate the value to the process, finding costs together with university timescales incompatible with their schedules [31]. According to PACEC [32] *'28% of academics interviewed believed that the inability of external organisations to meet the full costs of engagements constrained their interactions.*

Whilst the HE sector has the ability to incentivise academic engagement with the KT agenda, Government has a vital role to play in incentivising and making it easier for business to work with higher education if it is to meet its knowledge economy aspirations.

5 Conclusion

Whilst there are numerous documents and Government policies available that can chart the advancement of University–Business knowledge transfer, it can be argued that those written by Baillie, Robbins, Dearing, Lambert and Sainsbury provide a coherent overview of how knowledge transfer has evolved over time:- with roots firmly based in transferring knowledge through teaching and learning (the skills agenda) to initiatives that release and unlock the knowledge and expertise that exists within UK HEIs (the enterprise agenda), and finally to mutually beneficial knowledge sharing and the co-creation of knowledge between partners (the open innovation agenda).

Both universities and their business partners will benefit from a better understanding better of the critical factors required to support innovation that will have tangible outcomes together with real impacts whilst delivering value for money. Given the increasing shift of knowledge transfer into the institutional mainstream there is a continuing need to undertake more evaluation and research in a number of areas to both to help inform decision-making and assist U2B collaborations to maximise the benefits of knowledge transfer.

Indeed it is true to say that the KT is here to stay but the H.E. sector's ability to communicate, share, exchange existing, and create new knowledge through a wide variety of mechanisms is a critical factor to successful knowledge exchange. According to HEFCE's Strategic Plan 2006-11:

---

[10] http://www.brighton.ac.uk/profitnet An innovative business development and support programme that enables small and medium-sized enterprises to help themselves and their peers developed by the University of Brighton, it has been successful for over 600 businesses in the UK, Ireland and South Africa.

> "Sharing knowledge effectively is often as important as the original research and scholarship. Professional practice in knowledge exchange can be the engine of economic and social regeneration and the driver of business and institutional innovation. However, harnessing its potential depends on effective exchange between the discoverers of knowledge and its users" [33].

References

1. Baillie, J.B.: Industry and the university. Association for Education in Industry & Commerce (1925)
2. Becher, T., Kogan, M.: Process and structure in higher education, 2nd edn. Routledge, London (1992)
3. Committee on Higher Education, Higher Education Report of the Committee appointed by the Prime Minister under the Chairmanship of Lord Robbins 1961-1963, London, HMSO (1963)
4. DES, Higher Education, Meeting the Challenge, Cmd 114, HMSO (1987)
5. National Committee of Inquiry into Higher Education, Higher Education in the learning society (The Dearing Report), Stationary Office, London (1997)
6. Treasury, H.M.: Lambert review of business-university collaboration: final report. HM Treasury, London (2003)
7. Sainsbury, D.: The race to the top: a review of Government' science and innovation policies. H.M. Treasury, London (2007), `http://www.hm-treasury.gov.uk/d/sainsbury_review051007.pdf`
8. `http://www.hefce.ac.uk/econsoc/buscom/initia/`
9. Higher Education Funding Council for England, Higher Education Innovation Fund: invitation to apply for special funding. Higher Education Funding Council for England, Bristol (2001)
10. Higher Education Funding Council for England, Higher Education Innovation Fund round 2: invitation to apply for funds. HEFCE, Bristol (2003)
11. Higher Education Funding Council for England, Higher Education Innovation Fund round 3: invitation and guidance for institutional plans and competitive bids. HEFCE, Bristol (2005)
12. Higher Education Funding Council for England, Higher Education Innovation round 4: invitation and guidance for institutional strategies. HEFCE, Bristol (2008)
13. Argote, L., et al.: Knowledge Transfer in Organizations: Learning from the Experience of Others. Organizational Behavior and Human Decision Processes 82(1), 1–8 (2000)
14. PACEC & Centre for Business Research, Evaluation of the effectiveness and role of HEFCE/OSI Third stream funding, a report to HEFCE, report 2009/15 (2009)
15. ProTon, Experiences on the US knowledge transfer and innovation system (2007)
16. Howell, S.: Results from KTP primary research to improve engagement with academics: final report. University of Salford (2007)
17. PACEC & Centre for Business Research, OpCit (2009)
18. SEEDA, The role of Universities in raising the UK's Business Competitiveness (2010)
19. SHELL STEP, `http://www.sinc.co.uk/business_support/shell_step_programme.html`

20. Seely Brown, J.: Chief Scientist of the Xerox Corporation and Director of the Xerox Palo Alto Research Center. In: Chesbrough, H., Rosenbloom, R.S. (eds.) The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. Industrial and Corporate Change, vol. 11(3), pp. 59–555 (2002)
21. Tang, P., Weckowska, D., Hobday, M.: Disentangling knowledge transfer: Maximising university revenue, or social and economic benefit or both? A report prepared for the UKIPO (2008)
22. Rosa, P., Dawson, A.: Gender and the commercialization of university science: academic founders of spinout companies. Entrepreneurship & Regional Development 18, 341–366 (2006)
23. Choi, C.J.: Women and globalization: ethical dimensions of knowledge transfer in global organizations. Journal of Business Ethics 81, 53–61 (2008)
24. Thursby, J.G., Thursby, M.C.: Gender patterns of research and licensing activity of science and engineering faculty. Journal of Technology Transfer 30, 343–353 (2005)
25. Slaugther, S., Rhoades, G.: Academic capitalism and the new economy. John Hopkins University Press, Baltimore (2004)
26. Wellings, P.: Intellectual Property & Research Benefits – A report prepared for the Rt. Hon. John Denham, MP, Secretary of State for Innovation, Universities and Skill (2008)
27. Treasury, H.M.: Partnerships Uk, The provision of incentive schemes – additional information for PSREs and HNHS Trusts, a non-prescriptive guidance note for Public Sector Research Providers including Departmental and Non-Departmental Public Sector Research Establishments, NHS Hubs and NHS Trusts (2004)
28. Lock, D.: UNICO Salary & Incentives Survey, August 2007 (2009)
29. HOWELL, op.cit (2007)
30. Markman, G.D., Gianiodis, P.T., Phan, P.H., Balki, D.B.: Entrepreneurship from the Ivory Tower: Do incentive systems matter? Journal of Technology Transfer 29(3-4), 353–364 (2004)
31. SEEDA, op.cit (2010)
32. PACEC & Centre for Business Research, op.cit (2009)
33. HEFCE, HEFCE Strategic Plan 2006-11 (June 21, 2009) (updated June 2009)

Using Multiple Criteria Decision Analysis to Aid the Selection of Enterprise Resource Planning Software: A Case Study

Ross Parkhill[1], Valerie Belton[1], Umit Bititci[1], Alan Roberts[2], and Marisa Smith[1]

[1] University of Strathclyde, Glasgow, UK
e-mail: ross.parkhill@strath.ac.uk
[2] BHC Ltd., Medwyn Park, Carnwath, ML11 8HS

Abstract. BHC Ltd is a family owned SME which specialises in steel fabrication for the construction industry. Due to rapid growth over the past decade the company's current business software has evolved from a collection of semi-integrated individual packages and Excel spreadsheets. To help the company become more efficient during the current financial downturn and to ensure they are capable of future growth, BHC Ltd initiated a project with the University of Strathclyde to select and implement an Enterprise Resource Planning (ERP) solution.

This paper will provide a case study of BHC's ERP selection process. In particular it will discuss how steel specific business requirements and organisational culture led us to use multiple criteria decision analysis (MCDA) when making a final software selection. The MCDA process that was followed is further discussed and includes the success that was achieved by using this approach.

1 Introduction

This paper discusses activities undertaken as part of a Knowledge Transfer Partnership (KTP) No.6788 between BHC Ltd, a SME steel fabricator from South Lanarkshire and the University of Strathclyde, Glasgow.

The focus of this KTP project was on the design and implementation of an integrated software solution, in order to support estimating, planning and materials management. This was to be achieved through an ERP system, which will give BHC Ltd greater control and visibility of their processes allowing them to deliver jobs to site faster and more reliably, while also helping to facilitate the collection and analysis of data. This paper provides a case study of the methodology followed to select the correct ERP solution for BHC ltd, including the challenges that arose due to the culture within the organisation. The paper also discusses the use of multiple criteria decision analysis (MCDA) to aid the selection of an ERP solution and how this approach faired within the culture.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 39–49.
springerlink.com

2 Background

The Company

BHC Ltd design, manufacture and build structural steel and steel frame buildings for the construction industry. Founded in 1992 by Brian and Marjorie Hewitt, the company has grown rapidly over the last decade, increasing both their manufacturing facilities and capabilities at their base in Carnwath, Scotland. Their current markets include retail, leisure, industrial and agricultural buildings. Projects range from standard single span warehouses which are designed, manufactured and installed by the company, to large construction projects where the business only supplies and erects the structural steel work.

BHC Ltd aim to consolidate the company during the current market downturn, but envisage the potential for a future 30% growth in turnover. Beyond this the company plans growth into global markets (Europe and Asia) with additional manufacturing sites being added. To help ensure this growth is possible BHC have identified that they need to improve their current business software systems. The company has an existing MRP system and separate accounts package but this does not meet the business's growing needs for both volume and functional capabilities. The company's systems have not grown as the scope and volume of orders increased and a large amount of management time is spent on scheduling, manufacturing issues and manipulating current software or spreadsheets to retrieve vital data. The company made a decision in early 2009 that they would look to ERP software to eradicate these issues, initially considering building their own software before deciding that an 'off-the-shelf' solution was more viable.

Company Culture

It is widely recognised that different organisations can have distinctive cultures; the type of culture present within a company plays an important role in the ERP selection and implementation processes. Organisational culture itself is commonly described as 'the way we see and do things around here', and while this may be a simple statement it gives a good indication of how organisational culture can affect this type of project.

BHC is a family owned SME that can be categorised as an owner-manager organisation, where Brian Hewitt operates as both Managing Director and main stakeholder. Research into this type of organisation shows a firms' culture may be heavily influenced by the motivations, attitudes and management style of its owner-manager (Butler, 2006). Brian Hewitt is entrepreneurial in his approach to business. His own personal drive has not only been the main catalyst for company growth but also the reason BHC have successfully branched off into other non-steel opportunities. Brian Hewitt has achieved this success with a 'get up and go' attitude to business management often without any form of strategic planning.

The culture within BHC Ltd could be categorised as a 'power culture', based on the dominance of one or a small number of individuals within an organisation. They make the key decisions for the organisation (Handy, 1985). BHC Ltd does not have a board of directors or senior management steering groups to discuss and agree on business decisions or future strategy, all major decisions are taken by Brian Hewitt.

ERP Software

ERP systems are enterprise-wide software systems that support seamless integration of processes across functional areas including accounting, manufacturing planning and scheduling, supply chain management, human resources, Customer Relationship Management (CRM) and project management. ERP systems are designed to provide improved workflow, standardisation of business practices, and access to real-time information through the use of a common database for data storage.

Selecting an inappropriate ERP system is a major reason for ERP implementation failure. Due to the complexity of the business environment and the diversity of ERP alternatives, system selection can be a monotonous and lengthy task. Given the considerable financial investment and potential risks and benefits, the importance of selecting a suitable ERP system cannot be overemphasised since it is a decision on how to shape the organisational business (Teltumbde, 2000). Once the correct ERP system has been identified the process of actually implementing the software can begin. ERP systems are complex and implementing one can be a challenging, time-consuming and expensive project for any company (Davenport, 1998). Several things can affect the success of an implementation, these critical success factors (CSF's) include: top management support, vendor support, consultant competence, user support, IT capability and project manager leadership (Wang et al, 2008).

The selection and implementation of a suitable ERP system for BHC was given a two year project plan based on similar ERP projects that the University had managed. Although both these stages can provide their own difficulties, the selection of the correct software is critical to the overall success of the project. Often it can be extremely difficult to differentiate between ERP solutions due to the complexity of numerous considerations that should be taken into account. Therefore it was decided we would perform a multiple criteria decision analysis (MCDA) to help ensure BHC followed a structured decision-making approach.

Multiple Criteria Decision Analysis (MCDA)

MCDA can be defined as a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter (Belton & Stewart, 2002). One of the principle aims of MCDA approaches is to help decision makers organise and synthesise information in a way that leads them to feel comfortable and confident about making a decision, minimising the potential for post-decision regret by being satisfied that all criteria or factors have been properly taken into account (Belton & Wright, 2005).

Various models exist that can be used in a MCDA problem; these include value measurement models, reference level models and outranking models. Regardless of which style of model is selected a MCDA methodology can be used to:

- Take explicit account of multiple, conflicting criteria in aiding decision-making
- Help structure a problem, providing focus and a language for discussion
- Allow decision makers to learn about the problem situation, about their own and others values and judgments
- Provide an audit trial for a decision

The three key phases of the MCDA process are problem identification and structuring, model building and use, and the development of action plans. The selection process for determining the most appropriate ERP software among a set of possible alternatives on the market is a multi-criteria decision making (MCDM) problem (Karsak & Ozogul, 2009). Within BHC a MCDA methodology was used to aid the final decision making process.

4 A Case Study of Selecting an ERP Solution for BHC Ltd.

4.1 Process Analysis and Redesign

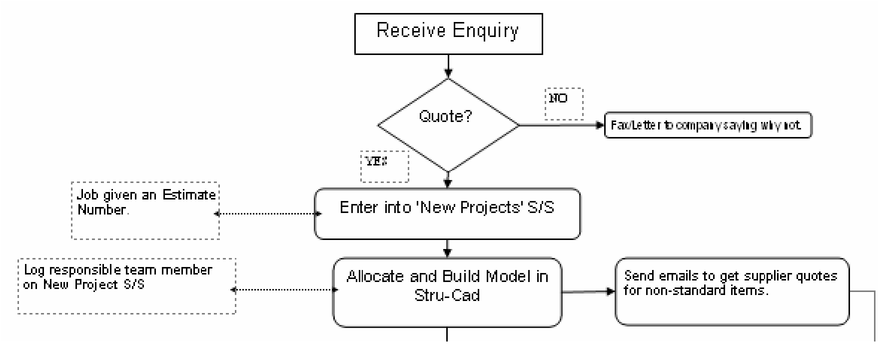
This initial project stage was aimed at redesigning the business processes within BHC. As the company has grown, many of their current processes and procedures have developed without considering optimisation or best practice approaches. The current system is greatly hindered by the number of disjointed software systems the company utilises.

Value Stream Mapping

Value stream mapping is a Lean technique used to analyse and map all the physical and information flows required to bring a product or service to a consumer. The tool was selected for BHC as it provides a clear way to illustrate the current and future state of a process. It is called a value stream map because it depicts the value-adding activities necessary to produce what the customer requires, in the sequence in which they happen.

In BHC we followed the standard process of firstly creating a current state map of the organisation. To achieve this we divided the full business into manageable subsections; Order Entry/Estimate/Tender, Purchase, Manufacture, Erect, Accounts. Taking each area individually we asked key personnel from associated departments along with a core project team, which was made up of key BHC individuals who had a broad overall business knowledge, to explain how the current process worked. This was drawn on a large piece of paper using 'post-it' notes to allow for quick and easy changes or additions. The current map detailed how each subsection functioned including all the interactions with other departments and how and where they use any software.

Once the current state was mapped, we brought the same groups back together to analyse the processes taking place. The aim of this was to identify inefficiencies like double handling and evaluate the use of the current software. From this we created a future state map, indicating how each subsection could operate more efficiently supported by improved software functionality.



The task of business process design, if carried out correctly, builds consensus about how the business will work in the future and makes clear the mechanisms through which pay-back will be delivered. This makes it much easier to identify essential software functionality and separate it from "nice to have" features. It also enrolls staff in the project (Okrent & Vokurka, 2004).

4.2 Requirements Specification

Redesigning the processes before selecting a software solution provided a solid foundation for developing a statement of requirements. Within BHC we gathered information throughout both the current and future mapping workshops, detailing areas that were highlighted as important requirements for BHC. The project team then met and produced the 'BHC ERP Business Process Requirements' document that summarised the major needs from each subsection of the business. It was agreed that this would form the basis of the full specification that would be sent out as part of the 'Invitation to Tender'. The full specification would be produced concurrently as we carried out the initial market research and vendor search.

4.3 Initial Market Search and Suppliers Selection

As BHC had initially considered writing their own ERP solution they had no prerequisites as to what ERP software they wanted to implement. Therefore the market research involved looking at the full spectrum of solutions on offer; this included full ERP solutions, modular software providers (accounts package, project management, planning and scheduling software) and steel-specific MRP/document management software. The internet provided much of the initial leads with several websites like the Evaluation Centre and the Technology Evaluation Centre providing excellent comparisons and software reviews. Individual supplier websites were also reviewed for case studies of companies similar to BHC or for experience in the construction or metals sector. Advice was also received from other KTP associates throughout the UK involved in ERP projects and from experienced University of Strathclyde staff. Research of what software other steel construction firms used was also carried out. Contact was made with all the larger members of the British Constructional Steel Association and telephone interviews held with IT or Production leaders.

From this initial research nine ERP software providers were identified, Epicor, Visibility, SAP, EFACS, IFS, M1, Infor, Microsoft Dynamics, Oracle and one steel-specific MRP provider StruMis. Each of these companies were provided with the 'BHC ERP Business Process Requirements' and asked to demonstrate their software on-site at BHC or provide a web demo. While this process was time-consuming with each demonstration taking up most of a day it allowed the project team to get an excellent feel for each piece of software as well as meet representatives of each company.

4.4 The Invitation to Tender (ITT)

During the software search and demonstration phase we continued to augment the BHC ERP Business Process Requirements document as we became more knowledgeable not only about our own true requirements but also by what we wanted from ERP software. To turn this into a full specification, input was received from key members of each department as well as senior management. The specification was then combined with details of the project and BHC data samples to form an ITT. This was sent to the ten software providers and each was asked to respond within a 3 week time scale.

We received nine responses to the ITT, and one further provider removed themselves from the running after further investigation into the solution required. Of the eight remaining, each response was evaluated individually against their ability to meet the key functional needs of BHC. All the information was analysed by the project team who then presented a shortlist to senior management that included three ERP providers and the steel specific solution. Both the initial demonstrations and the responses to the ITT identified that due to the nature of BHC's business, providing a fully functional solution was going to be complex process requiring several substantial changes to the 'out of the box' solution usually offered. At this point it was agreed by the project team and senior management that we would be unable to make a final selection from the evidence we had seen so far and that a second round of more in-depth demonstrations should take place.

4.5 Software Workshops

To aid the final selection process we needed to delve deeper into the functionality each software could offer and in particular understand how each solution would deal with the core requirements of BHC's business. These specific steel industry processes were not something any of the full ERP systems could deal with as standard and due to this there was a feeling of risk towards going with this type of solution. However the steel specific MRP solution, while handling core requirements well, lacked additional functionality which would result in a final solution with multiple software packages connected together.

To help elevate fears of using a full ERP system we sent each of the three ERP providers a full package of data that included a complete BHC project and asked them to demonstrate how this job would move through their software. This was an extensive test and each workshop was held over two days within the BHC plant. We also decided to use this opportunity to involve more BHC staff as we realised this would help with the change management process during and after implementation. Working with each department and utilising the specification we identified what the critical functionality was for each department. We then produced a scoring sheet and asked each department to send representatives to the appropriate section of the workshop and score each piece of software. This allowed future end users to directly contribute towards the final selection and helped promote a feeling of ownership towards the decision, this is something that could prove vital during the difficult stage of implementation and go live.

4.6 Final Software Selection Process

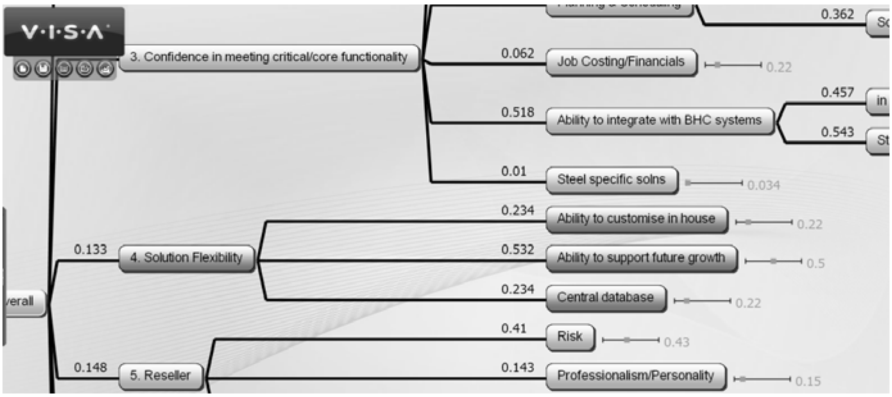
Although the final workshops were beneficial for various reasons we still could not differentiate significantly enough between each software package to select a final solution. Each individual software solution had its own particular merits or shortcomings, however it was proving difficult to view all these considerations as a whole and compare each overall package against each other. Also, as the process to this point had been extremely time-consuming senior management had been unable to attend all the reference site visits and workshops. Although the project team were confident that an ERP solution could be achieved, the steel specific solution was being increasingly considered as a reduced risk option.

At this point we decided to utilise our links with the University and carryout a multiple criteria decision analysis (MCDA). There was some concern about attempting MCDA within BHC as the company had no experience in this approach and it was not normal to BHC's culture. However as this was a KTP project the University wished to ensure that BHC were exposed to well-founded decision-making processes and followed a structured methodology to arrive at an evidence-based justifiable selection. However, it is important to recognise that MCDA is an aid to decision making and that the 'preferred' outcome depends on the values of the decision makers. It would therefore be down to the management to decide whether they wished to go with the software identified through the MCDA, or to review the priorities reflected in the model.

To aid the MCDA process we used Web V•I•S•A software, a multi-criteria decision support system which is based on a multi-attribute value function (www.simul8.com). The use of such an approach greatly facilitates the consideration of differing values and opinions through the provision of a focus for exploration and discussion of a problem (Belton, Ackermann & Shepherd, 1997). Through a serious of meetings with BHC management and University staff we used a top-down approach to identify the following six high level criteria:

- Cost - including software licenses, implementation costs, maintenance and support costs
- Software functionality - as demonstrated in workshops
- Confidence in meeting critical/core functionality
- Software flexibility and configurability
- Reseller considerations - including risk, staff personality, support
- Implementation strategy

These were then broken down further into sub-criteria which we could score each of our four final solutions against. This information was collated utilising the Web V•I•S•A software to form a decision value tree.

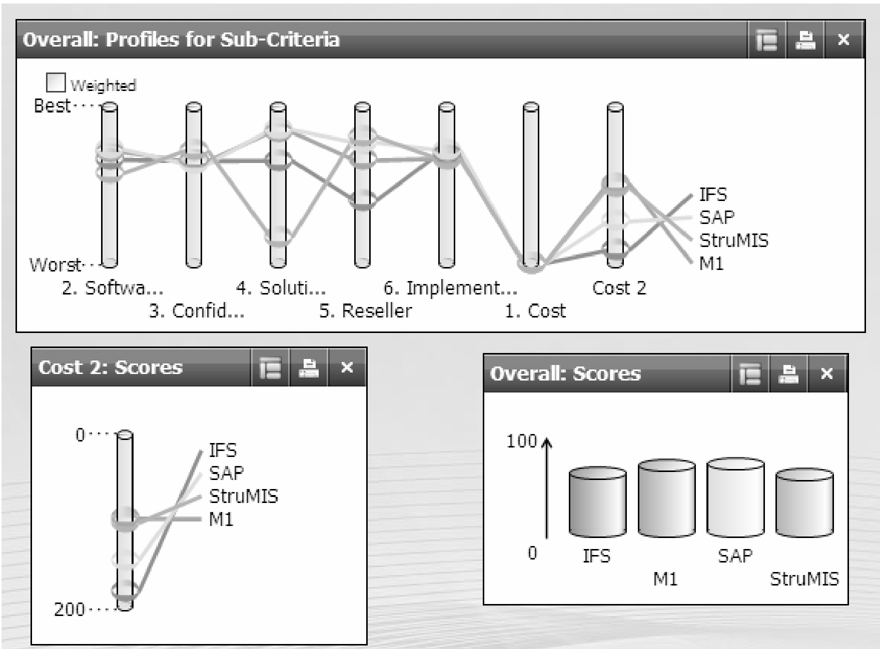


We then brought all the major project stakeholders together for a half day decision-making session. This was held in the University to provide focus and minimise disturbances. Using the Web V•I•S•A value tree, as a group we went through each sub-criterion scoring the four possible solutions. A zero to one hundred scoring system had been agreed at the start of the meeting with clarification on how the system should operate. The process of scoring each sub-criterion generated enthusiastic group discussion, with many questions and system challenges being raised.

Each of the sub-criteria and six high level criteria were then weighted to reflect their 'importance' against BHC's ERP requirements and overall business needs (where the notion of 'importance' captures the relative value of moving from 0 to 100 on each criterion). This stage provided further interesting debate as many of the stakeholders had differing views as to what they deemed the most important factors. This process provided a platform for everyone to express their views and helped provide clarity on what was important to BHC as a whole. In particular it allowed BHC management to address what had now become the two key issues:

- The risk involved in selecting an ERP solution as apposed to the steel specific software
- Quantify the benefits additional ERP functionality can bring to BHC

Once the scoring and weighting process was complete Web V•I•S•A software was used to show the results graphically. This visual representation showed clearly the ranking of how each solution performed. Further experimentation with different scenarios was carried out, in these 'what if' scenarios we changed the weighting of key criteria and reviewed how this affected the overall results. This process enabled us to prove the original findings as even when changing various weightings one supplier continued to perform strongly.



At the close of the meeting it was agreed by all stakeholders that we had now identified a preferred supplier for the management to consider.

5 Discussion and Conclusion

This case study detailed the steps undertaken to select an ERP solution for BHC Ltd. Although we followed a widely accepted methodology, complexities arose due to the nature of the business and culture that exists within the organisation. Full ERP systems are not common within the steel industry; throughout this project we could not find another UK or European steel fabricator with an 'off the shelf' solution in place. Due to this, many of the steel specific problems had never been tackled by any of the ERP providers we approached. This made evaluating each piece of software extremely difficult and led to an extended period of market research and workshop testing.

The inability of potential suppliers to demonstrate fully a system that could meet BHC's requirements made senior management nervous and resulted in the strengthening of the case to select the steel specific Material Requirements Planning (MRP) software. However this solution would only provide some of the benefits that BHC initiated this project to deliver. Investigating ERP software and attending reference site visits or software workshops proved to be a very time-consuming task, therefore Brian Hewitt was unable to make all the scheduled appointments. This resulted in the project team being empowered to drive the project and find a suitable solution. However as the final decision date drew closer there was uncertainty around the correct way forward as even the project team could not unanimously decide on a preferred solution. This was mainly due to the multiple, often conflicting, criteria that must be considered when selecting an ERP system.

To help with the decision process and ensure BHC followed a structured approach when identifying the correct solution we turned to Multiple Criteria Decision Analysis (MCDA). There were concerns about using such an approach due to the organisational culture and normal decision-making process within BHC Ltd. However this process proved to be a massive success with excellent feedback from BHC management and members of the project team. With the aid of Web V•I•S•A software we were able to structure a complex decision and provide a platform for extensive discussion on the correct software choice. This lead to a better considered, justifiable and explainable decision being made; something that could prove invaluable during the difficult stages of implementation and the change management process.

This type of formal decision-making is not normal to BHC's culture; however the process of MCDA proved to have added value in this type of organisation as it forced key BHC individuals to think and discuss a major decision through as a team. The MCDA process ensured that company owners could now make a final selection with confidence and a full understanding of why the ERP software was the correct decision for the business.

References

Belton, V., Ackermann, F., Shepherd, I.: COPE-ing with V·I·S·A: Integrated Support from Problem Structuring through to Alternative Evaluation. Journal of Multicriteria Decision Analysis (1997)

Belton, V., Stewart, T.J.: Multiple Criteria Decision Analysis: An Integrated approach. Kluwer Academic Publishers, Dordrecht (2002)

Belton, V., Wright, G.: Making Decisions, The Graduate School of Business, University of Strathclyde (2005)

Butler, D.: Enterprise Planning and Development: small business start-up survival and growth. Butterworth-Heinemann, Butterworths (2006)

Davenport, T.H.: Putting the enterprise into the enterprise system. Harvard Business Review (1998)

Handy, C.B.: Understanding Organizations, 3rd edn. Penguin Books, Harmondsworth (1985)

Karsak, E., Ozogul, C.: An integrated decision making approach for ERP system selection. Expert Systems with Applications 36 (2009)

Okrent, M., Vokurka, R.J.: Process mapping in successful ERP implementations. Industrial Management + Data Systems (2004)

Teltumbde, A.: A framework for evaluating ERP projects. International Journal of Production Research (2000)

Wang, E., Shih, S., Jiang, J., Klein, G.: The consistency among facilitating factors and ERP implementation success: A holistic view of fit. The Journal of Systems and Software 81 (2008)

Applying the Structural Complexity Management to Knowledge Transfer in Small and Medium-Sized Companies

Maik Maurer[1], Hermann Klinger[2], and Alexander Benz[3]

[1] TU Muenchen, Institute of Product Development, Boltzmannstr. 15, 85748 Garching, Germany
e-mail: maik.maurer@pe.mw.tum.de
[2] Festo AG & Co. KG, Ruiter Straße 82, 73734 Esslingen, Germany
e-mail: kli@de.festo.com
[3] LMU München, HWZ, Goethestr. 31, 80336 München, Germany
e-mail: abez@applied-knowing.org

Abstract. Retention and transfer of personnel knowledge represents a fundamental competitive factor for small and medium-sized companies (SMEs). A major problem is that increasingly unavailable specialists remain at a company for less time, but generate more complex knowledge during their time of employment. A methodical knowledge transfer designed for this specific problem situation of SMEs has to meet the requirements of high transfer frequency and short time slots for transfers while still maintaining a high quality of transferred knowledge. Knowledge transfer must be easy to implement. In cooperation with Festo we created an approach to knowledge transfer using methods of Structural Complexity Management. Advantages of the approach include its uncomplicated application and limited resource needs. Resulting analyses and visualizations allowed employees to focus on relevant knowledge aspects to be transferred effectively.

1 Initial Situation

In the unfolding knowledge economy the environment of companies is becoming increasingly dynamic. Products and services are becoming more knowledge driven and interdependent. Small and medium-sized enterprises (SMEs) are developing and producing more and more products that require intense technical knowledge (e.g. for controlling the constraints in complex production processes). The retention and transfer of personnel explicit and implicit knowledge represents a fundamental competitive factor for these companies. This knowledge assures the company's core competences and preserves its unique characteristics. That's the reason why the retention and preservation of knowledge is sometimes also referred to as the memory of the company (Papoutsakis 2009).

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 51–60.
springerlink.com

In the past, companies were able to preserve their knowledge. But with outsourcing, lean management and reengineering parts of the organizational memory are getting lost. More and more corporations recognize that they need to take initiatives to safeguard or bring back what constitutes their organizational memory.

Technical-driven solutions for the transfer and retention of knowledge have gained more economical importance lately. These solutions tend to neglect the various forms of knowledge and the dependencies that make bits of information useful and valuable for the colleagues and the company (Bergeron 2003).

The Festo AG & Co. KG (Festo) represents a medium-sized company developing and producing solutions for automation problems in different industries and application fields. The company has implemented a variety of knowledge management projects for typical themes like innovation projects and competitor information. Guided by the company's appreciation and high regard of their employees and their knowledge, Festo has (within the framework of an employee life-cycle-management) introduced a process of knowledge transfer from leaving or retiring executives to their dedicated successors. Typically, such transfer processes are realized by questionnaires, informal interviews and the handing over of documented explicit information.

Festo introduced additional forms of transfer to stimulate also the communication of implicit knowledge: An in-house consultant acquires important knowledge components from experts by interviews. The resulting collection is transferred to a mind map and serves for comparison with the available knowledge components of the successor (also acquired by interviews). Subsequently, the discrepancy in familiarity of specific knowledge components can be used to focus the communication and the project work of the expert and his successor on the relevant topics.

2 The Problem

Today knowledge management is a challenge for all companies intending to survive in a knowledge society and which intend to maintain or improve their competitive position. The optimization of many classical production factors seems to be exhausted but the improvement potential of managing knowledge is just starting to be unlocked (Probst et al. 2006).

Organizations and their employees are forced to acquire more knowledge in shorter time than in the past. At the same time the half-life of existing knowledge is decreasing (Machlup 1962; Botha 2008). So the necessity to learn and implement a culture of ongoing lifelong learning is growing.

With increasing dynamics and complexity of projects, implicit knowledge and knowledge concerning dependencies become more important. Simple knowledge of the existence of colleagues, products and development stages seems to be trivial; however, an expert knows which colleague is required for which product (or specific product problem) in which development stage. That means that the documentation and transfer of information and facts can only represent the rudimentary basis of a successful knowledge transfer.

Experts possess explicit and implicit knowledge on important dependencies – and this knowledge is difficult to communicate to other employees. Typically, only facts are documented and made available. The decisive dependencies and implicit connotations are neglected or get lost in a transfer process (see Figure 1).

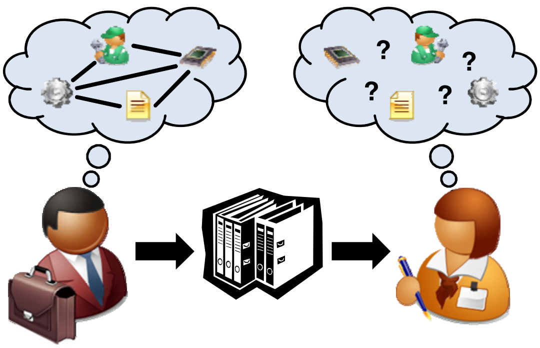


Fig. 1 Transfer of knowledge facts without consideration of dependencies

A pragmatic method of knowledge transfer is realized with the application of mind maps (Buzan and Buzan 2001): Relevant facts are classified in categories and depicted in tree structures (Eppler 2004). This method only considers hierarchical relationships but no logical dependencies.

If the knowledge of a resigning expert is of essential importance for a company, the knowledge transfer is often realized by shared project work of the expert and his successor. This is time-consuming and cost-intensive and can only be executed if the pending retirement of the expert is known at an early stage.

Knowledge management systems are mostly inadequate for SMEs. The effort required for system installation and support is high; and such systems require considerable resources for a continuous acquisition of knowledge.

Fluctuations in employment increase continuously due to greater flexibility of people during their working life. Not only in cases of employees' retirement, but already after few years on the job the knowledge transfer between employees has to be initiated. In the case of an employee's retirement a long-term knowledge transfer can be initiated, as the time of retirement is known in advance. However, the short notice fluctuations in employment allow only short time slots for knowledge transfer.

In SMEs, relevant knowledge of technology is often concentrated with few or even single employees. For the future job market a decrease of available skilled employees is predicted. That means that less available specialists remain at a company for less time, but generate more complex knowledge during their employment. This results in the need for a highly effective and efficient method of knowledge transfer that can be applied without intense prior preparation.

3 The Approach

A methodical knowledge transfer designed for the problem situation of SMEs has to meet the specific requirements of high transfer frequency and short time slots for transfers while still maintaining a high quality of transferred knowledge. SMEs usually do not have readily implemented continuous knowledge management; often, knowledge transfers are initiated on demand. For this reason, the transfer method must be easy to apply for involved employees. The approach presented in this paper involves a moderator (Figure 2). Knowledge exchanging employees need not be method experts and can concentrate on the transfer of content. As networks of linked knowledge components can become complex, software applied for the Structural Complexity Management has been adapted.

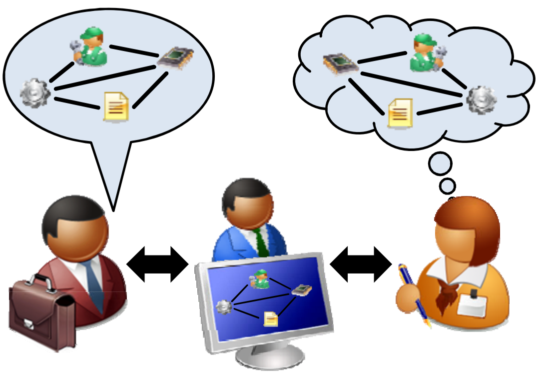


Fig. 2 Transfer of linked knowledge components supported by a moderator and tools

The new approach for executing the knowledge transfer (Figure 3) can be classified in four steps. The initial system definition results in a collection of required knowledge domains and their general linking (represented by a system graph or a Multiple-Domain Matrix). In the subsequent information acquisition (step 2) knowledge components (within the domains) and their direct dependencies are collected in an interview with the expert. The knowledge receptor is then confronted with the acquired list of knowledge components and clarifies his familiarity with them. In the third step of the approach the acquired knowledge components and dependencies are visualized to provide system transparency and possibilities of interaction. In the fourth step, the knowledge network (acquired from the expert) and the status of familiarity with the knowledge components (acquired from the receptor) are analyzed to answer two questions:

- Which knowledge components receptors require for executing relevant tasks?
- Which differences exist between the expert and the knowledge receptor in the handling of tasks and competences?

Answering the first question allows concentrating on the transfer of the most important (packages of) knowledge components. Answering the second question makes it possible to delve into the details of executing the daily project work. In the following sections the four steps will be explained in detail.

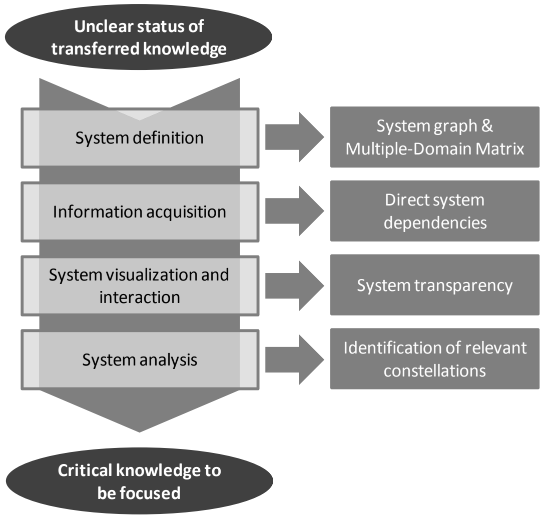


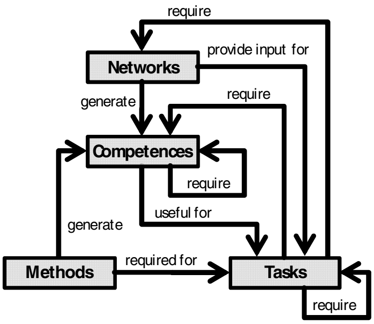
Fig. 3 Four-step approach on knowledge transfer for SME

3.1 System Definition

Relevant domains have to be identified, which allow a classification of the expert's knowledge components. These domains can be defined on a generic level or deduced from a prior collection of knowledge components. In the specific use case at Festo the following four domains were already determined in a similar transfer process: tasks, competences, methods, and networks.

The general dependencies between the domains were defined with the expert. The resulting system graph can be seen on the left side of Figure 4. An alternative matrix representation is shown on the right side of the figure. This depiction complies with the general layout of a Multiple-Domain Matrix (MDM) (Lindemann et al. 2009) and possesses advantages in the information acquisition discussed next. The domains written in the row headers link to the domains in the column headers with the dependency description specified in the matrix cells.

As the applied domain indications and dependency descriptions are rather generic the created system definition could be further applied to several similar knowledge transfer projects. This reduces further effort on system definitions.



	Tasks	Compe-tences	Networks	Methods
Tasks	require	require	require	
Compe-tences	useful for	require		
Networks	support	generate		
Methods	required for	generate		

Fig. 4 System graph and Multiple-Domain Matrix (MDM)

3.2 Information Acquisition

Knowledge components within the four identified domains have been acquired by interview with the expert. The process was systematized by creating a mind map (Buzan and Buzan 2001). 80 relevant knowledge components were subsequently assigned to the four domains.

The identification of explicit dependencies between the single knowledge components represents the most important and time-consuming part of the information acquisition process. For the execution of this task the acquisition procedure provided by the method of Structural Complexity Management (Lindemann et al. 2009) has been adapted to the knowledge transfer project:

Dependencies between knowledge components have been acquired by expert interviews supported with matrix visualization. This matrix is based on the one created in the system definition (Figure 4); now the domain names are split up into the knowledge components. Thus, the matrix cells containing the dependency descriptions in Figure 4 have been expanded to sub-matrices. Now, the advantage of representing the system definition in matrix form becomes clear: The 80 knowledge components form a matrix containing 6320 matrix cells. The systematic consideration of these cells would be time-consuming. However, empty cells in Figure 4 do not possess any dependency description and therefore need not be considered in the information acquisition process. As in our use case seven out of 16 sub-matrices do not possess a relevant dependency description, almost half of the element pairings can be excluded from consideration in the information acquisition process. The practical acquisition required a single workshop day involving the expert and a moderator. The expert became familiar with the procedure very quickly and reacted in a focused manner.

Once the matrix of linked knowledge components has been acquired from the retiring expert, next the knowledge of the successor had to be examined. In the best case, a successor would fill out the same matrix as the expert. This would allow the identification of the differences between both employees and the deduction of the necessary focus of knowledge transfer; but this procedure requires many resources. In our specific project situation detailed information acquisition with knowledge receptors could not be executed, because the expert's knowledge should be transferred to four people (due to reorganization of the work group). Thus, the transfer with the successors had to be limited to a minimum – which represents a typical industrial situation. Consequently, knowledge receptors were only asked about their current familiarity with and further required input on the knowledge components acquired together with the expert. Through this procedure, knowledge receptors only had to consider 80 components – and did not have to specify thousands of dependencies. Each interview took only about one hour.

3.3 System Visualization and Interaction

This part of the transfer project provides transparency for available knowledge. At Festo we realized an intuitive representation of the expert's network by using the software LOOMEO (http://www.teseon.com). The expert specified more than 800 dependencies. That means that representing the entire network can not provide deeper insight. However, the local surrounding of specific knowledge components can be helpful. Here, the LOOMEO software provides the possibility to browse the network's structure starting from one specific element in question. If one element is selected, the linked knowledge elements are shown (see Figure 5).

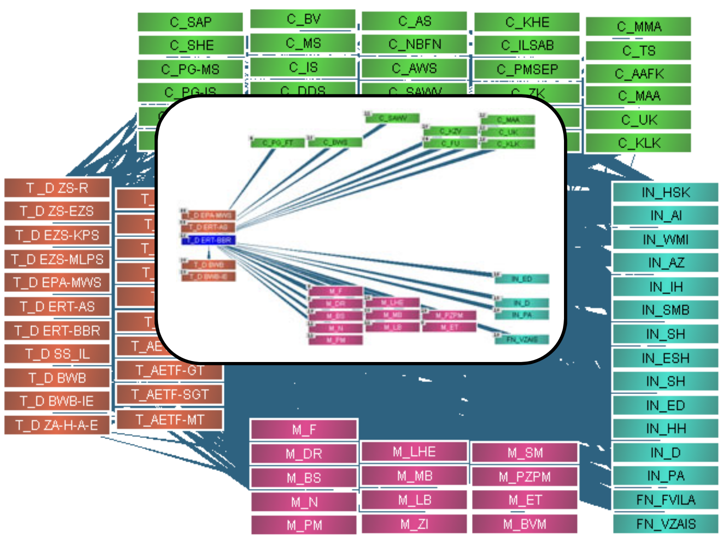


Fig. 5 Entire graph of linked knowledge components and specific viewpoint

The figure shows the entire network in the background (knowledge components have been made anonymous). The knowledge components have been arranged in four blocks according to their domains. Dependencies between the components are so numerous that they can not even be distinguished.

In the foreground the passive surrounding of one knowledge component is depicted. For one specific task it is highlighted:

- Which tasks require and which networks support the tasks in question
- Which competences are useful and which methods are required for processing the task in question

The graph representation and its possibilities for interaction allow problem specific access to the complex knowledge network. At Festo, the expert used selected viewpoints at single elements for verification of the acquired dependencies. Knowledge receptors used this possibility to closely study knowledge aspects that seemed unclear to them.

3.4 System Analysis

So far, knowledge components and their dependencies have been acquired from the expert; the degree of familiarity of four knowledge receptors with these knowledge components has been acquired. Based on this information an analysis has been undertaken that led to the answers of two questions:

- Which knowledge components does the receptor require for executing relevant tasks?
- Which differences exist between the expert and the knowledge receptor in the handling of tasks and competences?

Figure 6 shows the schematic graph layout for answering the first question. The depiction indicates the four domains and dependency meanings between included elements with arrows. Here, only knowledge components are visualized, which have been specified by knowledge receptors as being unfamiliar. For the analysis the focus is set on the non-familiar tasks. If such a task is not linked to any competences, networks or methods the knowledge receptor lacks no precondition for carrying it out. Thus, the receptor possesses all required input and can be directly confronted with the task at hand in the daily project work. If, however, further knowledge components are linked to a task, these competences, networks and

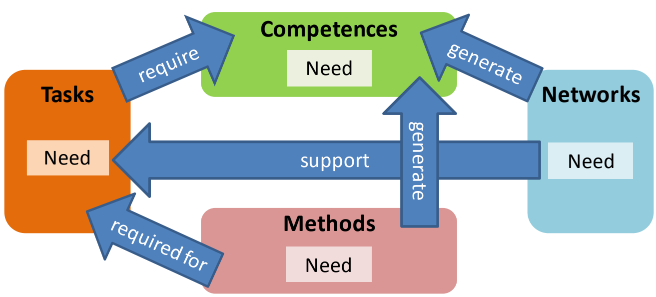


Fig. 6 Dependency and element meaning for analyzing constellations of relevant knowledge

methods have to be transferred to the receptor in combination with the task itself. So, the result of the first analysis can be summarized as follows: The expert is able to focus on required knowledge packages that include combined knowledge aspects and that can be mediated, e.g. in practical project work.

Figure 7 shows the schematic graph for answering the second question. In contrast to Figure 6, only the knowledge components that the knowledge receptors are familiar with are visualized in the tasks and competences domains. If in this visualization a specific task is connected to a network or method, a discrepancy in task processing exists between the expert and the knowledge receptor. Because the dependencies have been specified by the expert, he has declared that the connected networks and methods are relevant for fulfilling the task. The knowledge receptor, despite having specified the task as familiar, is not familiar with the related networks and methods. The knowledge receptor can process the specific task, but without applying the same knowledge as the expert. Thus, the second analysis can be summarized as follows: The analysis provides the awareness of different task handling approaches of the expert and other employees. This handling can then be subjected to closer discussions that focus on the identification of best practices.

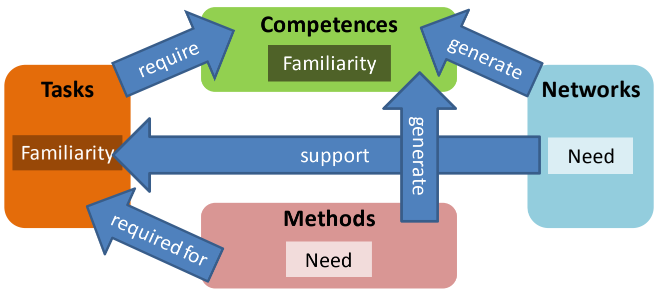


Fig. 7 Dependency and element meaning for identifying different handling of tasks

4 Results

The analysis provided an overview of the state of the knowledge transfer process between the expert and four knowledge receptors. The receptors had a very different background with regards to their period of employment and work experience. Because of these differences the previously applied knowledge transfer via mind maps was not useful: E.g., knowledge receptors with a detailed work experience but only short period of employment at Festo would declare many knowledge components in the mind map as being unfamiliar. Even though these knowledge receptors have a lot of experience, they are not familiar with the specific company wording or methods. So, the expert would have to exert a large amount of effort to transfer knowledge of working aspects that the receptor is mostly familiar with.

In contrast to previous knowledge transfer procedures, the new approach allows for creating specific knowledge packages that have to be transferred or further discussed. That means that within a highly complex knowledge network, employees can focus the discussion efficiently on relevant aspects. In the presented use case at Festo six person-days were sufficient for identifying the receptors' individual needs concerning further knowledge transfer from the expert.

5 Conclusion

A fundamental need of SMEs is a methodical knowledge transfer process designed to meet the specific requirements of high transfer frequency and short time slots for transfers while still remaining a high quality of transferred knowledge. The newly created approach displayed good usability in practice. Involved employees did not need intense method training and had to invest little time in the information acquisition part of the approach. The systematic analysis provided significant knowledge packages for closer consideration by the expert and knowledge receptors. Herewith, the approach could simplify and accelerate the knowledge transfer process with a required amount of effort which is acceptable for SMEs.

References

Bergeron, B.: Essentials of knowledge Management. John Wiley & Son, Hoboken (2003)

Botha, A.: Knowledge. Juta Academic, Lansdowne (2008)

Buzan, T., Buzan, B.: The Mind Map Book. BBC, London (2001)

Eppler, M.: Making Knowledge visible through knowledge Maps. In: Holsapple, C. (ed.) Handbook of knowledge Management, vol. 2. Springer, Heidelberg (2004)

Lindemann, U., Maurer, M., Braun, T.: Structural Complexity Management – An Approach for the Field of Product Design. Springer, Berlin (2009)

Machlup, F.: Knowledge production and distribution in the United States. Princeton University Press, Princeton (1962)

Papoutsakis, H.: Organizational Knowledge Sharing Networks. In: Girard, J. (ed.) Building Organizational Memories. Idea group inc., Hershey (2009)

Probst, G., Raub, S., Romhardt, K.: Wissen managen, 5th edn. Verlag Dr. Th. Gabler | GWV Fachverlage GmbH, Wiesbaden (2006)

Teseon GmbH, LOOMEO software for the structural complexity management (2009), `http://www.teseon.com` (Accessed June 8, 2009)

Establishing a Business Process Management System in a Telecoms Company

S. Green[1], Ali Abughoush[3], Ian Beeson[1], Tim Hill[2], and Justin Nwakacha[1]

[1] University of the West of England, Bristol, UK
[2] Gamma Telecom Ltd., Newbury, UK
[3] Devoteam Middle East, Riyadh, Saudi Arabia

Abstract. Gamma Telecom provides voice services and voice applications. But newer products are increasingly more complex and the largely manual processes involved in order fulfilment are unable to perform effectively enough. As a result Gamma and the University of the West of England (UWE), in a joint Knowledge Exchange Partnership (KTP) project, are investigating how to automate such product processes using Business Process Management System (BPMS) technology within a Service Oriented Architecture (SOA) development framework. A number of product processes have been automated, and the resulting experience and knowledge has been incorporated into a "meta-process", a process for capturing, modelling, analysing, improving, and providing IT support for Gamma's new business product processes. It is suggested that a generalised form of this "meta-process" would benefit other companies wishing to pursue process automation.

1 Introduction

Gamma Telecom is a UK provider of voice services and voice applications, switching around 8 billion minutes per annum and supplying services via its resellers to about 100,000 UK businesses and approximately 400,000 residential customers (Gamma 2008).

But new products that Gamma sought to introduce were significantly more complex to order and support than traditional voice services. For example, to fulfil an order for one of Gamma's current products, the company needed to place one simple order with one supplier. A typical new product, on the other hand, required knitting together orders placed across 10-15 different suppliers and careful management of the interdependencies between these separate suppliers. The company was finding this virtually impossible to do, as well as proving expensive in staff costs. In addition, orders were taking too long to fulfil.

In order to address these challenges, Gamma decided to adopt an infrastructure that would support the automation of different business activities, and thereby help the company to manage its services in a more robust and efficient manner. It was predicted that the introduction of a modern workflow system (better known as a

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 61–68.
springerlink.com

Business Process Management System, (BPMS)) (Ould 2005; Weske 2007) and more generally a drive towards a Service Oriented Architecture (SOA) (Erl 2007) would help Gamma to not only address immediate business problems but also to provide a new core capability upon which it could build new products not yet conceived. In using the BPMS and SOA approaches, the definition, design and execution of efficient business processes would require investment in requirements gathering, in consulting interested parties, and in defining the human and software resources that would interact with the process, as well as a communication protocol (Jennings et al. 2000).

To address all of these concerns, Gamma embarked upon a Knowledge Transfer Partnership (KTP 2008) project with the University of the West of England (UWE). The overall objective of the resulting KTP is to develop a new core capability within the business: the ability to automate processes using a BPMS within an SOA approach. The KTP consists of two interdependent projects:

- The first project is concentrating on developing and embedding a method and governance framework for process automation covering: process analysis, design, modelling, simulation, deployment and continuous improvement.
- The focus of the second project is on implementing the most appropriate BPMS and its requisite technical infrastructure.

Against this background, we are now developing a meta-process for identifying, modelling, analysing, improving and automating Gamma's business processes.

Operationally, the KTP project identified distinct roles for two associates, one to be concerned primarily with process elicitation, modelling, analysis and improvement, and the other with process automation implementation using a technology set comprising a BPMS, web services (Alonso et al. 2004), and an Enterprise Service Bus (Chappell 2004). Both associates were to be involved in developing the process for automating processes, i.e. with the meta-process referred to above.

In the event the second, more technical, associate (Justin Nwakacha) was not able to start until one year after the first associate (Ali Abughoush). This meant that the meta-process has been developed in two main phases, the first dominated by design and the second by implementation. The two associates have been managed by Tim Hill, and the participating academic staff are Ian Beeson and Stewart Green.

The paper is structured as follows. The next section describes methods, that were used both to transfer knowledge and, more particularly, to create knowledge. Section 3 describes the key knowledge that was created, i.e. the meta-process. After this, in section 4, we describe how this knowledge is being disseminated within the organisation, including through the use of seminars given by the current associate. Section 5 concludes the paper by reiterating its main deliverables and outlining future work.

2 Knowledge Creation: Building a Process Development Meta-process

This section discusses how knowledge was both transferred from the two academics to the KTP team - associates, associates' line manager, and line manager's manager -and how knowledge was created by the KTP team and the academics working together.

Knowledge was transferred from the academics to the KTP team in the following main ways:

- Discussions at regular meetings
- Literature recommendations
- Course recommendations
- Tool recommendations

For example, at one of the regular meetings, the first associate was made aware of the existence of Ould's *Riva* method for identifying an organisation's process architecture (Ould, 2005). Identifying such a process architecture is potentially very relevant to this KTP because the architecture's constituent processes could be used to select from among Gamma's business processes particular processes for automation. The academics explained the *Riva* method to the associate and followed the explanation with references to Ould's book on *Riva* (Ould 2005).

Similarly, knowledge was transferred from the KTP team to the academics during discussions and through reports summarising process automation work. For example, the first associate created a report for each Gamma business process that he identified, captured, modelled, analysed, improved and supported using the BPMS. The reports contained, for instance, details of the XML schemas (XML 2003) used to describe messages passed to and fro between services comprising an improved, automated process. And the processes themselves were specified using the Business Process Modelling Notation (BPMN) graphical models (BPMN 2007). So through studying these reports, the two academics improved their knowledge of contemporary BPMS technology.

The critical knowledge that was created by the KTP team and the academics working together was the *meta-process*, an evolving process for automating a succession of selected Gamma business processes. This knowledge was created using the following method, which was suggested by the academics and developed and put into practice by the two associates.

Starting in the first iteration with a straw-man meta-process (identify, capture, model, analyse, improve and automate), the associates, in tackling a series of projects in Gamma, would follow the current version of the meta-process, record and reflect on their use of the meta-process in the current project, and review and revise the meta-process for use in the next project. One effective way of recording and reflecting on experiences in this development work proved to be the maintenance by the associates of a blog.

The meta-process is described in more detail in the next section. As the associates have embarked on increasingly complex Gamma projects, the meta-process has been refined, and strategic knowledge has been created for the organisation.

3 The Meta-process

What we refer to as the 'meta-process' is a key longer-term contribution of the KTP project at Gamma Telecom, because it provides a regular method for redesigning business processes at Gamma and implementing them within the BPMS/SOA framework. By repeating the same general method of conversion, and refining it as experience accumulates, the BPMS approach and its associated technologies become gradually established in the company, and each new implementation, while inevitably bringing its own challenges with it, becomes more straightforward, because it uses a method that has already been shown to work, and with which analysts and developers at Gamma are increasingly familiar. The meta-process has two principal aspects to it:

- an iterative aspect: each BPM project at Gamma follows a regular development process, as defined at the time of the project;
- a cumulative aspect: experience from each successive project produces learning about the development process itself, which is distilled and feeds forward into refinements of that process.

As originally envisaged, the meta-process has four broad phases to it: envisioning, design, implementation and testing. These are focused on the iterative aspect of the meta-process. These were established in outline during the first year of the KTP project. Because of the way the project unfolded, however, with the first associate strongly focused on design, and the move into implementation delayed until the arrival of the second, the detail of the first two phases (envisioning and design) was worked out before that of phases 3 and 4 (implementation and testing). These are the four phases of the meta-process:

1. **Envisioning phase:** understanding how the existing process works and defining its limitations, then deciding whether the process is suitable for BPM implementation by measuring it against the 'BPM acid test' (see below and (Havey 2005)).
2. **Design phase:** designing a model in BPMN that shows how the improved process will be automated and defines the messages that will be exchanged between the process and its related services.
3. **Implementation phase:** implementing the process by adding Web Service Definition Language (WSDL) files (WSDL 2007) to the BMPN diagram, applying the XML schemas that will be used for defining the messages between the web services, applying error handling mechanism and converting the BPMN diagram into executable code that is ready to be deployed on a BPMS server.
4. **Testing Phase:** deploying the process on a test BPMS server and testing its functionality by executing test cases that cover different scenarios for triggering the process.

The constituent steps in each of these phases will now be presented in outline. Although Implementation and Testing were originally seen as separate phases, they are in fact interconnected and have proceeded in parallel. We show this here by embedding testing within implementation. Phases 3 and 4 have therefore been combined in what follows, and a new phase is defined, called Incorporation, which captures the cumulative aspect of the meta-process.

3.1 Envisioning Phase

The envisioning phase includes the following steps:

1. *Identify a process for BPM implementation*: meeting project stakeholders to define a process at Gamma that needs to be optimised to enhance the company's operations.
2. *Perform stakeholder analysis*: identify the key people that may significantly influence the successful analysis and implementation of the process; draw a stakeholder diagram.
3. *Understand the initial process*: interview stakeholders; capture the end-to-end process definition; analyse other process definition sources; identify process limitations and areas for improvement.
4. *Apply the 'acid test' for BPM implementation*: use Havey's test (Havey 2005) for process-oriented applications – which should be long running, idle most of the time, and in need of 'orchestration' (coordination of system or human communication).
5. *Create a business modelling document*: this gathers all the details on how the current process works, its limitations and areas and improvement.
6. *Analyse the development effort*: meet the software architect and development manager at the company to identify the changes and additions that need to be applied to the existing systems to make it suitable for automation (e.g. web services to be developed, code changes to existing components, stored procedures to be developed, database tables to be built/modified).

3.2 Design Phase

The design phase includes the following steps:

1. *Model the process in BPMN*: create a graphical representation of the process using BPMN to show how a proposed process is triggered and then invokes different system services.
2. *Validate the design with stakeholders*: check understanding and modify diagram as necessary.
3. *Define process XML schemas*: agree on the input and output messages that should be exchanged between the new process and existing systems (messages between invoker and process, and between the process and services it invokes; and fault messages).
4. *Create a design document*: this should include the BPMN diagram, a description of the process's lifecycle, and the XML schemas.

3.3 Implementation Phase

This stage involves implementing the XML schemas and the operations depicted on the BPMN diagram in order to create an executable process that can be deployed on a BPMS server. It includes the following steps:

1. *Implement a demonstration process*: define WSDL files for the processes in the diagram; as proof of concept, use dummy web services to return predefined responses back to the process.
2. *Prepare and execute test cases*: prepare a list of the possible input XML requests and run them against the test interface, to check whether actual responses match expected responses.
3. *Implement the real process*: develop the real web services (using Java Business Integration (JBI) components) and correct any errors discovered during the demonstration implementation, then replace the operations of the dummy services with the operations of the actual JBI components, applying error handling to catch any fault messages returned from the services and send them to the invoker.

3.4 Incorporation Phase

As each successive project of conversion of a Gamma process into the BPM framework is completed, the opportunity arises to learn from it and to consolidate the knowledge gained into a broadening and maturing practice of business process management at the company. This can include the following aspects:

1. Refining the envisioning, design and implementation phases to reflect the experience and learning on the recent project.
2. Refining and extending the set of essential business entities (Ould 2005) that characterise the work of the company. In Gamma's case, these include customer, switch, order, number, trouble ticket, and payment.
3. Identifying and implementing entity-centric services to handle these critical entities. By developing consistent and thoroughly tested services for handling key entities, manual handling and the need for ad hoc intervention can be reduced, services can be re-used, and the level of automation is increased.
4. Building a process repository. Once entity-centric services have been implemented, they can be indexed and stored in a directory that can be accessed by different processes requiring that service.
5. Disseminating the knowledge gained into the wider organization.

This last aspect is developed further in the next section.

4 Knowledge Dissemination: Embedding the Meta-process within the Organisation

Transferring knowledge to people of different disciplines is challenging. It is Gamma's intention that a significant proportion of their business processes will be automated. Therefore one major goal of the KTP is to embed knowledge of the meta-process, as well as the knowledge and skills of related technologies, e.g. Java, Java Message Service (JMS), and BPMS, within the organisation. In particular the business analysts and software developers will need to be very familiar with the meta-process and associated technologies, but managers and other employees will also need to be aware of them.

A number of ways have been suggested for embedding this knowledge and the associated skills. These include:

1. Company wiki
2. KTP blog
3. Lunchtime seminars
4. Technology workshops (BPMS, JMS, Java, SQL)

By themselves, making the meta-process documentation available on the company Wiki (knowledge base) and publishing the KTP blog internally are probably insufficient to encourage people to use this technology. Some staff might not even know it is available on the Wiki. One solution to leverage the advantages of the meta-process was to inform staff through lunchtime seminars. The meta-process contains detailed information, but the seminar is meant to notify the people of the meta-process's existence (per project), and give an overview of the technology driving the project, and its advantages. The seminars allow other staff to expose their difficulties, which they hope the technology would help solve.

Gamma Telecom organizes seminar sessions every two weeks, so the avenue for delivering this had been setup. Alongside the meta-process is a Power Point presentation of the seminar. The seminar on the meta-process lasted for an hour and was attended by the associated software development team.

In addition to lunchtime seminars, workshops have been organized for the teams that rely on the technology described in the meta-process. The introduction of this technology will affect the way they carry out their jobs, so it is not just a workshop, it can also be seen as an interactive session where these teams can be convinced that the impact of this change can be managed. The information dispersed will be more detailed, unlike the lunchtime seminar, whose audience cut across users of different technology. The format of the workshops will be:

- Introduce the technology and meta-process
- Outline its advantages and limitations
- Indicate what problems it will address
- Describe the likely impact on the team
- How changes would be managed
- Assure the team that support will be provided
- Answer any questions

These methods that have been tried have been found to be effective in embedding the knowledge in the organisation. The most effective method was the lunchtime seminar because it had a larger audience and because it wasn't detailed – so people listened attentively. It also provided a medium for feedback which helped in all of the following: revising the meta-process, finding a suitable time to deliver the seminars / workshop, selecting the audience, updating the wiki frequently, and informing interested staff of the updates.

5 Conclusions

The paper has described, first, the two-way transfer of knowledge between Gamma and the academics about business process management systems; second, the joint creation of a meta-process for automating Gamma's business process products; and third, some ideas about how to embed the meta-process, i.e. the newly created knowledge, into the organisation.

The key deliverable to date has been the meta-process. It is suggested that if this were generalised then it would be very useful to other companies at the same technology level that wished to pursue automating their business processes in an SOA development framework.

In the future, the meta-process will be further refined through its application to increasingly complex Gamma business product processes. In addition, the meta-process seminar and related technology workshops will be refined, run again, and refined once more for further deliveries. Associated work with the development of entity-centric services and of a process repository will also be taken forward.

References

BPMN, Business Process Management Notation (BPMN) Information (2007), http://www.bpmn.org (accessed January 28, 2008)

Chappell, D.: Enterprise Service Bus. O'Reilly, Sebastopol (2004)

Erl, T.: SOA: Principles of Service Design. Prentice-Hall, Englewood Cliffs (2007)

Gamma, Gamma Telecom (2008), http://www.gammatelecom.com (accessed January 28, 2008)

Havey, M.: Essential Business Process Modelling. O'Reilly, Sebastopol (2005)

KTP, Knowledge Transfer Partnership (2008), http://www.ktpoline.org.uk (accessed January 27, 2008)

Ould, M.: Business Process management: A Rigorous Approach. Meghan-Kiffer Press, Tampa (2005)

Weske, M.: Business Process Management. Springer, Heidelberg (2007)

WSDL, Web Services Description Language (WSDL) Version 2.0 Part 1: Core Language (2007), http://www.w3.org/TR/wsdl20/ (Accessed June 29, 2009)

XML, XML Schema Part 0: Primer Second Edition (2003), http://www.w3.org/TR/xmlschema-0/ (Accessed June 23, 2009)

Alonso, G., Casati, F., Kuno, H., Machiraju, V.: Web Services: Concepts, Architectures and Applications. Springer, Heidelberg (2004)

Jennings, N.R., Faratin, P., Norman, T.J., O'Brien, P., Odgers, B., Alty, J.L.: Implementing a Business Process Management System Using ADEPT: A Real World Case Study. Applied Artificial Intelligence 14(5), 421–463 (2000)

Critiquing Business Process Models to Facilitate the Identification and Selection of Optimal IT Systems

Stewart Green[1], Stephen Batty[1], Mike Back[2], Joe Jewell[1], and Martin Webber[2]

[1] University of the West of England, Bristol
[2] Space Engineering Services Ltd., Bristol

Abstract. In common with many SMEs, Space Engineering Services Ltd supports a number of business process variants found in different parts of the organisation for achieving the same organisational goals using non-optimal IT. In order to address these problems, the capability to use role activity diagrams (RADs) for organisational process modelling was introduced by this Knowledge Transfer Partnership (KTP) using three knowledge transfer mechanisms: a short course on RADs, expert feedback on initial RAD models, and feedback on initial process elicitation efforts. The resulting learning was adopted and adapted by the KTP team into a process that is being used to improve many of the company's critical strategic processes, and also to identify optimal IT support for those processes. It is expected that this process would benefit many similar SMEs.

1 Introduction

Space Engineering Services Ltd was founded in 1988 and provides refrigeration, air-conditioning, mechanical and electrical services. In 2007 it was the market leader, by market share, in the industrial refrigeration retail sector and its key customers included Tesco, Sainsbury and some of the other big supermarket chains. The company had grown rapidly and was forecasting an annual turnover of £140M and Earnings before Interest and Tax (EBIT) of £8.9M at the end of 2007. Space Engineering Services Ltd has employees in several UK locations and provides services UK wide.

The directors of Space Engineering Services Ltd at that time were concerned that the company's core business processes and IT systems had remained largely unchanged as the company had grown. Areas of particular concern included:

- some processes and IT systems were disconnected
- some existing IT systems were not scalable so they could not support more users
- some existing systems could not be developed further to support current and future management information requirements
- opportunities may have been being missed to exploit IT to improve business performance.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 69–78.
springerlink.com

To address these problems, the company joined forces with the University of the West of England and made a successful bid for KTP. It was expected that the primary outcome of the KTP project would be the successful implementation of new or substantially improved processes and IT systems at Space Engineering Services Ltd. In addition, a secondary output was expected to be that the company would be left with capability to model and improve business processes using Riva (Ould 2005).

In order to achieve the primary and secondary outcomes, knowledge of business process modelling using Ould's *Riva* method was transferred to Space Engineering Services Ltd by the UWE academics on the KTP. This paper describes the techniques that were used to effect this transfer, as well as describing how this knowledge was subsequently adopted and adapted into a critical, strategic process for identifying and selecting cost-effective, contemporary IT solutions.

The paper has the following structure. Following this introduction, section 2 describes the technology that was transferred, i.e. *Riva's* Role Activity Diagrams (RADs) for modelling business processes. Section 3 describes the three main techniques that were used to transfer knowledge about RADs and about how to do RAD modelling. Following this, section 4 describes how RAD modelling was adopted and adapted into a critical, strategic process for identifying cost-effective, contemporary IT solutions to support the company's improved processes; it also exemplifies the use of this process by showing how it was applied to improve, and support with new IT, some Human Resources (HR) systems. After this, section five summarises the key benefits to the company of using RADs. And section six summarises the paper, restates the main conclusions, and outlines future work.

2 The Technology: Modelling Organisational Processes Using Role Activity Diagrams (RADs)

Organisational business processes may be modelled using Role Activity Diagrams (Ould 1995 and 2005), the notation for which is presented in Appendix 1. According to Ould, "a *process* is a coherent set of *actions* carried out by a set of collaborating *roles* to achieve a *goal*" (Ould 1995), where a *role* is deemed to be a responsibility within a *process*. Within a *role*, *actions* are connected by lines depicting the *state* pertaining before an *action* and the *state* pertaining after it. Particular *states* may be identified by a *state description*, which is often used to denote the *goal* or outcome of a *process*. *Start role* is an action that instantiates a new *role* instance of a specified kind.

A *state* may be tested and different threads followed thereafter depending upon the results of the test; this is modelled using the *case refinement* notation. At other times a state may be divided into a number of concurrently performed threads; and this is modelled using *part-refinement*. Whenever the same sequence of actions is repeated, the *replication* notation may be used.

Roles collaborate by means of *interactions*. If one role is the initiator of the *interaction*, the *driver interaction* notation may be used in a model.

The *stop* notation is used optionally to mark the end of a thread, and the "*don't know*" notation is used to model parts of the *process* in which the modeller is not interested.

As an example of a RAD, consider figure 1, which depicts the initial business process in the company for entering and authorising invoices. Here, we can see four roles; one represents the invoice administrator, another the software application Cedar, and two others represent files. The process begins when an "Invoice arrives", this triggers an interaction initiated by the "Invoice Administrator" who enters a PO number on the Cedar system. If the number is not correct, then the Cedar system will return an appropriate error message to the "Invoice Administrator"; otherwise it will return the purchase order details. The remainder of the process is built from similar building blocks so need not be described here.

RAD models are deemed to be superior to other process modelling notations like flowcharts, because they enable more information relevant to a business to be represented in a model. For example, roles can be used to represent the key active responsibilities in model; these may be people, or software applications, or data stores, for instance. RADs can also easily show the interactions between two or more roles, which can be used to model real-world interactions between responsibilities in a business process

3 Transferring the Technology

Three different techniques were used to transfer to company employees the capability to model organisational processes using RADs, as follows:

- A half-day course "Modelling Organisational Processes Using Role Activity Diagrams"
- Academic feedback on RADs created by the KTP Associate
- Academic observation and feedback on the elicitation and critiquing of a Company business process by the KTP Associate

3.1 Short Course

At the beginning of the KTP, four members of the KTP team at the company – the Associate, the Business Development Manager, the IT Manager, and a Business Analyst – attended a short course given by one of the KTP academics.

The course comprised a presentation and two group exercises. The presentation covered Ould's RAD notation (Ould 1995; Ould 2005) and strategies and heuristics for analysing and improving business processes. The first exercise required two pairs to each create and present a RAD model from a supplied business scenario; and the second required the pairs to create an improved business process RAD model, annotated with appropriate supporting IT, from a concrete and abstract version of an initial business process.

Feedback on the course by the attendees was very positive.

3.2 Feedback on RADs

Three weeks after the short course, the KTP academic received a number of RAD models that the Associate and the Business Analyst had created in the course of understanding and modelling business processes found in different parts of the organisation. The academic reviewed each model and marked up incorrect notational use and other anomalies. Subsequently he visited the Associate and Business Analyst on site and discussed their initial attempts at RAD modelling. In addition to correcting use of the RAD notation, the academic also validated the extent to which each process as modelled actually represented the Associate's and Business Analyst's understanding of the corresponding process.

As a result of this feedback, subsequent RADs were of a higher quality.

3.3 Feedback on Business Process Elicitation and Critiquing

Shortly after providing feedback on the Associate's and Business Analyst's first RAD models, the academic observed the Associate eliciting the supplier invoicing business process from the company employee responsible for this process. The Associate was able to suggest some possible changes to the process as the elicitation discussion proceeded. Other changes were made after the as-is process had been modelled as a RAD (see Figure 1, below) and critically reviewed. The resulting to-be version of the process is modelled in the RAD shown in figure 2.

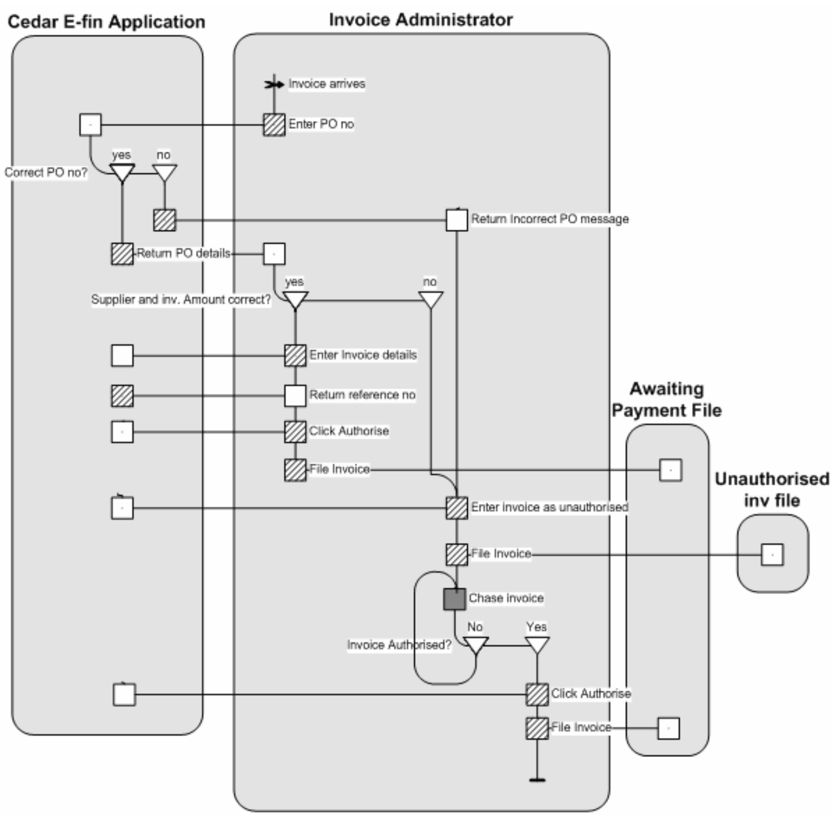


Fig. 1 RAD for the as-is invoice entry and authorisation process

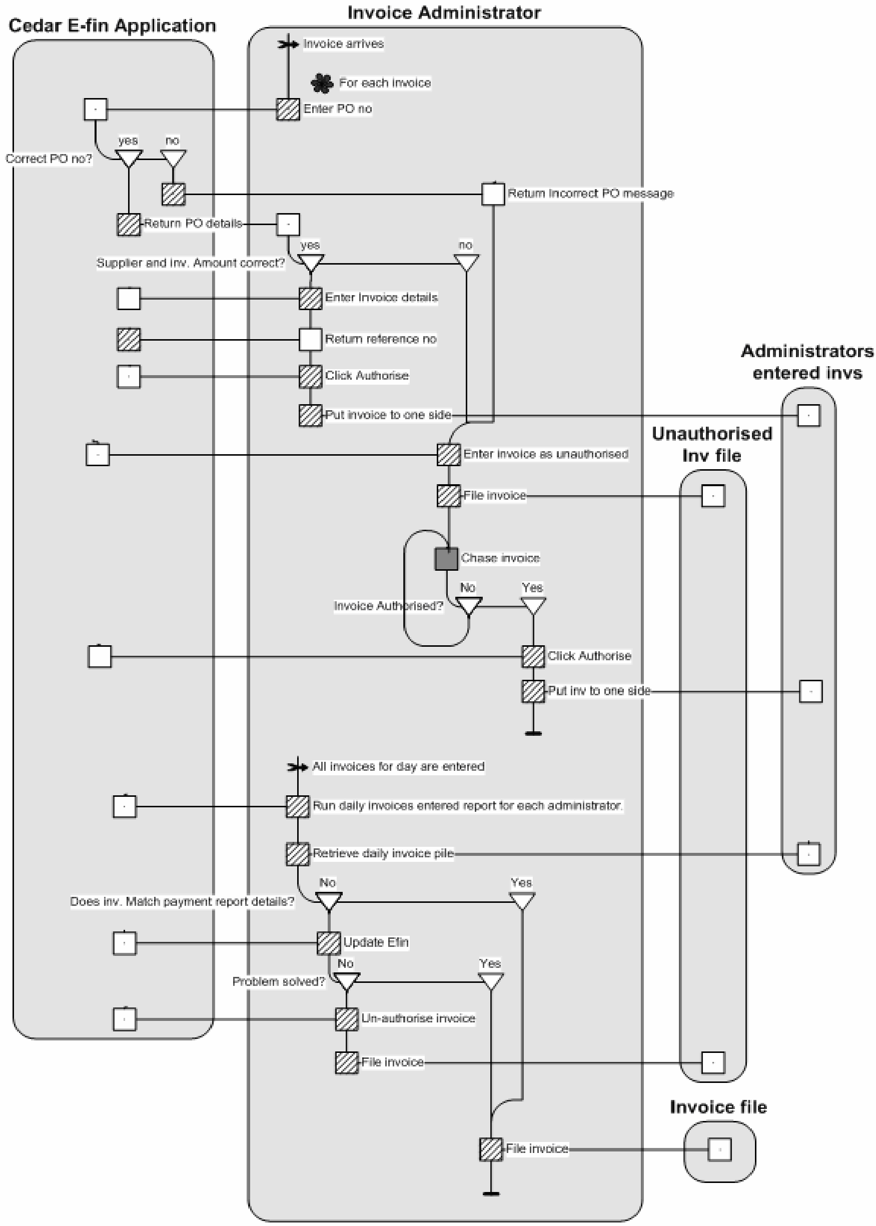


Fig. 2 RAD for the to-be invoice entry and authorisation process

4 Developing and Using the Technology

Ould has proposed a three stage process-improvement process (Ould 2005, p.24):

- "draw up the current concrete process model"
- "'abstract' it to yield the current abstract model"
- "find a better way of implementing it in a new concrete model"

Here, an abstract process model is intended to capture the intent or purpose of roles, actions, interactions and events for a modelled process; in a hypothetical abstract process model, one action might be: "Create definitive documentation". A concrete process model**,** on the other hand**,** is intended to capture the concrete mechanisms of, for example, actions or interactions. Such a model might include, for example, the activity "Complete online form 21A located at www. whatever".

The topic of the process-improvement process was covered on the short course described above. Once it had been learnt, the Associate and others in the KTP team adapted it; next they incorporated the adapted process into a larger process that is now being used extensively in the KTP project to both improve the company's business processes, and to identify appropriate IT for supporting the improved processes. This larger process has the following main steps:

1. Elicit from the stakeholders the as-is process and model it as a RAD
2. Critique the as-is process, including any supporting software, in order to improve it, and model the resulting to-be process as a RAD
3. Analyse the to-be process (RAD) to identify areas for IT support and their associated functional requirements
4. Incorporate the requirements in a specification and put it out to tender to companies identified through market research
5. On the basis of responses from the companies, short-list the best and invite them in to demonstrate their IT products
6. Assess the demonstrations using predetermined criteria and, on the basis of the assessment, reduce the short list.
7. Undertake reference site visits for products from companies on the reduced short list
8. Select the company with the best IT offering and open negotiations with it.

In the adapted and extended process that has been created on this KTP, we can see that Ould's second step is carried out implicitly: intentions are derived from reviewing the as-is process model and, although not formally modelled, are used to derive better ways of meeting them in what become the improved, to-be processes.

The adapted and extended process was used to improve a number of the company's critical strategic business processes including, for example HR. The complete list includes:

- HR system
- Service management system
- Finance system

The following example, where the adapted, extended process just described was applied to the company's HR processes, illustrates how the process is used and how it derives its efficacy.

Figure 3 shows the then current as-is business process for the "holiday request" function with the organisation. This process is one element from the set of functions supported by an HR product in use at the company which we will call here X-HR.

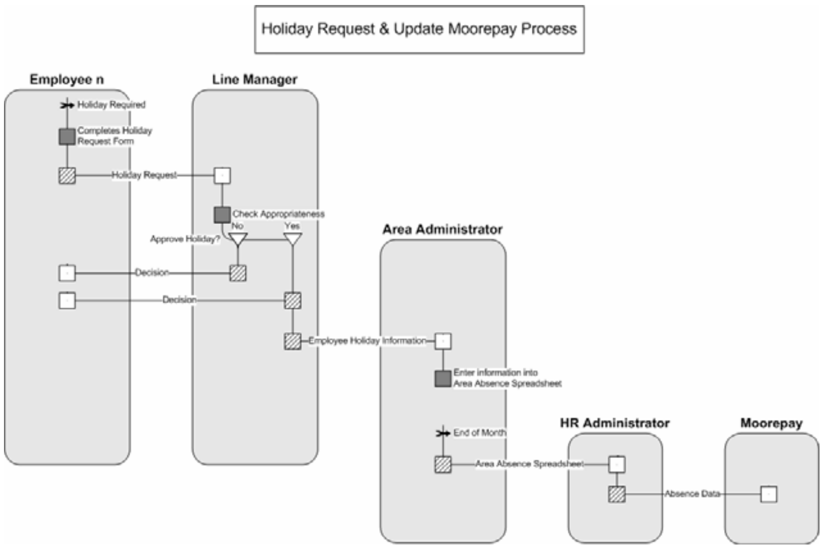


Fig. 3 Holiday Request and Update Moorepay Process

A review of this process indicates that it is relatively complex, involving five interacting roles for employees to book their holidays. In addition, it is clear that holiday request information has to be rekeyed multiple times by various company employees. Investigation indicated that four days were needed to complete this process.

The review further indicated that complexity, elapsed time and cost might be reduced if the employee was able to interact directly with an HR software system. And this key requirement formed the cornerstone the requirements for a new HR software system that was developed.

In addition to the problems associated with the process, there were also problems intrinsic to the X-HR software product in use: it wasn't easily scalable or customisable, it didn't allow for creation of new report types, it could not be connected to other systems, and so on.

Market research identified eighteen potential suppliers, each of which was sent the requirements specification and invited to tender. Eleven did so. Each response was scored and the companies were ranked; each company's product price was also ranked. On the basis of these rankings five companies were invited to demonstrate their HR products; and each product was assessed in terms of ten criteria such as "Self Service", "Workflow Definition", "Usability", and so on. Based upon the result, two HR systems were short listed: Vizual and one other. Visits were made to a company that used Vizual's product and also to a company that used the other company's product. The upshot as that Vizual was chosen as the preferred supplier, and negotiations with them were opened.

Figure 4 depicts the RAD model of the holiday request HR process supported by Vizual's HR.net. It shows a process where employees can try to book holidays by directly entering holiday request data into the HR.Net system. In addition, the need for the work of the Area Administrator and HR Administrator has been removed.

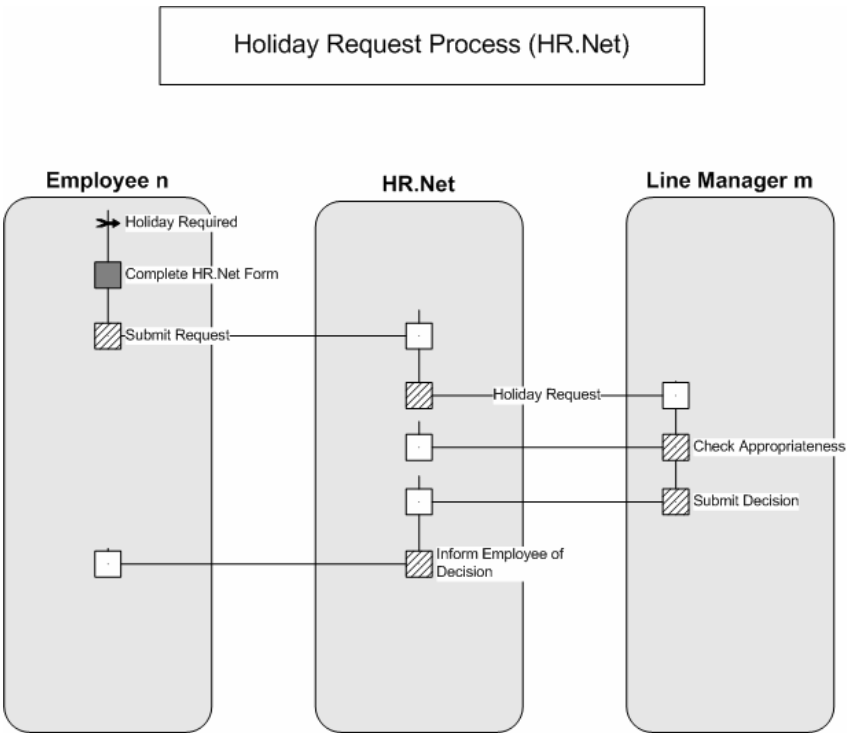


Fig. 4 Holiday Request Process (HR.Net)

It has been predicted that the company will save in the order of £3,000 to £3,500 annually on the cost of supporting the holiday request process using the new process and new HR.Net product. Furthermore the total savings for all of the HR processes are estimated to be of the order of £11,000 to £11,500.

This example has illustrated the usefulness of RAD modelling of business processes, the transferred technology, for helping to identify the requirements for improved business processes and improved IT systems when the RAD modelling is incorporated into a more comprehensive process improvement and IT selection process.

5 Benefits of the Technology

RAD models are better than more traditional process modelling notations like flow charts because more relevant information can be expressed with their notation: for example, involved organisational roles can be easily and clearly represented. This is fundamental to transforming a business as organisations comprise a combination that includes people, roles, activities, interactions, and processes.

The capability to model organisational processes using RAD models has provided a number of benefits to Space Engineering Services Ltd as follows:

1. RAD models have facilitated the adoption of an evidence-based approach to investigating internal processes: once processes are understood then measurements can be put in place, and more accurate "what-if" predictions about, for example, future process performance can be made under a variety of circumstances.
2. Through the analysis of RAD models, more appropriate IT can be identified, which, in turn, can lead to cost savings.
3. Once tacit knowledge has been unlocked and captured in RAD models, it is easy to communicate this process information among company employees, and, as a consequence, they come to understand such processes better and more quickly.
4. The activity of creating and analysing RAD models facilitates the creation of better business processes. In addition, it facilitates the identification and repair of both broken business processes and incoherent business processes.

6 Conclusion

The paper has described how Ould's Riva RAD modelling method for modelling business processes was transferred to Space Engineering Services Ltd as part of an established KTP project. The theoretical and practical knowledge about RADs was intended to address some of the key strategic problems being experienced by the company, for example, that in 2007 some processes and IT systems were disconnected. The knowledge transfer was effected using a short course, academic feedback on early modelling efforts and academic feedback on early process elicitation and modelling efforts. It was deemed to have been successful because the use of RADs has become integrated into this KTP project. In fact RAD modelling has been incorporated into a larger, critical strategic process for identifying appropriate, cost-effective contemporary IT support for improved processes. This larger process has become the de facto way of selecting new IT within the company.

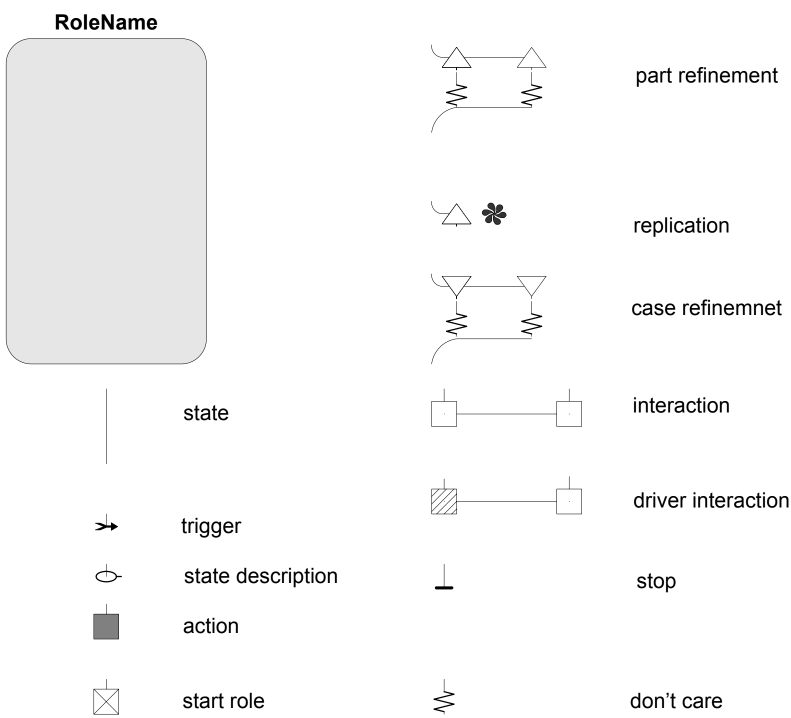
Future work on the KTP project will examine the production of both and information and a process architecture (Ould 2005; Green et al. 2009) with a view to optimising the integration of related systems.

References

Ould, M.A.: Business processes: modelling and analysis for re-engineering and improvement. John Wiley, Chichester (1995)
Ould, M.A.: Business process management: a rigorous approach. BCS, Swindon (2005)
Green, S., Beeson, I., Kamm, R.: Reusable process architectures and process models: an experience report from higher education. International Journal of Business Process and Integration Management (2009) (to appear)

Appendix

Role Activity Diagram: Key to Notation



Outcomes and Benefits of a Knowledge Transfer Partnership in Chemical Science

Ian J. Bradshaw[1,*], Linda Seton[1], and Neil Rosenburgh[2]

[1] School of Pharmacy and Biomolecular Sciences, Liverpool John Mores University, Liverpool L3 3AF, UK
e-mail: i.j.bradshaw@ljmu.ac.uk
[2] Salt Union Ltd, Astbury House, Bradford Road, Winsford, Cheshire CW7 2PA

Abstract. Knowledge Transfer Partnership (KTP) is a UK initiative to enable companies to benefit from the knowledge and skills within Universities. A recent chemically based KTP between Liverpool John Moores University and Salt Union Ltd provided a range of benefits to the University, Company and Associate. The transfer of knowledge to the Company has resulted in the development of a research capability, optimised products and an increase in profits. The Associate has gained commercial experience, enhanced qualifications and training, and at the culmination of the funded programme, was appointed within the Company at managerial level. The academic staff from the knowledge base partner have developed their research standing, gained commercial awareness and enhanced their teaching with industrial case studies and projects.

1 Introduction

Collaboration between academia and industry is important to improving the economies of countries in the modern world. There are a number of different schemes that are used worldwide for knowledge transfer and these have been reviewed and assessed in recent years (Galbiati *et al*, 2001; Graca, 2005; Hofer *et al*, 2001; Valentin and Sanchez, 2002). As well as improvements to competitiveness in companies and research in academia respectively, these schemes can also provide a wide range of other outcomes and benefits as described in this paper.

In the UK, the government is committed to increasing the knowledge transfer between Universities and Industry (DIUS, 2008; DfES, 2003). The Knowledge Transfer Partnership Scheme, (KTP), and its predecessor Teaching Company Scheme, (TCS) has been running since 1975, during which time over 5000 such collaborations have taken place between Academia and Industry. Knowledge Transfer Partnerships is considered to be Europe's leading programme to help businesses improve their competitiveness and productivity by using available knowledge, technology and skills in UK universities (Technology Strategy Board, 2008).

---

* Corresponding author.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 79–89.
springerlink.com

KTP facilitates the partnership between an industrial (or company) partner and a knowledge-based partner (University) to allow a business to tackle a project that is core to its strategic direction. A structured work plan (1-3 years) that allows knowledge to be transferred from the academic institution to the company is devised for the project. The three-way partnership is completed by the recruitment of a KTP associate (a well-qualified graduate) to manage the project. The associate is an employee of the University for the duration of the programme but spends the majority of time working at the company partner. The scheme has traditionally been targeted at small to medium sized enterprises (SMEs), which may not have the resources or knowledge capability to undertake the research, development or expansion that their company needs to grow its business.

The company is able to benefit from the knowledge and skills of the academic partner, as well as indirect benefits such as use of University facilities or equipment. Indeed, the scheme facilitates a project that would not be possible for the company to conduct alone. The expected outcome is that the implementation of the work programme will lead to significant growth of the business in the three years following completion.

The academic staff from the knowledge base partner involved in the partnership can expect to enhance their research portfolio, and develop their research base by working on a commercial research programme. Also, it is expected that the nature of the study will lead to other avenues of investigation being identified, which the academic staff can then pursue separately from the main research programme. In addition, the process of problem solving within the operations of a commercial organisation will lead to case studies which can be developed for teaching material that has commercial relevance, thus providing a stimulating and exciting learning environment for undergraduate students.

The knowledge base partner benefits from the research income associated with the KTP programme, the development of links with the company partner and the development of its research staff. The funding covers the associate salary, training budget, equipment and consumables. In addition, the budget pays for the consultancy time of the academic staff as well as indirect costs for the University.

This paper describes the outcomes and benefits to the three partners arising from a KTP between Liverpool John Moores University and Salt Union Ltd, A Compass Minerals Company.

2 Description of the KTP Programmme

2.1 Expectations of the Programme

The main business of Salt Union Limit Ltd (SUL) is the mining, processing and supply of rock salt for winter maintenance of roads. At the start of the KTP, the company had begun to offer to the market a premium salt which had been treated with an agricultural by-product (ABP) that conferred enhanced de-icing performance and inhibited the corrosive effects of salt. The company wished to develop this product, and to explore the possibility of alternative ABPs which were predicted to increase profitability. Further, the company recognized that the technical support team had neither sufficient chemical knowledge nor the research and development capability required to assess fully the potential of existing ABPs or any possible alternatives. As well as requiring the chemical expertise of the knowledge-based partner to address this objective, the embedding of a robust product development capability within Salt Union was a stated aim of the project.

The objectives of the programme covered a broad remit and included those that were knowledge led, such as the investigation of the mechanisms of corrosion inhibition and the gathering of data to evidence the enhanced performance of the premium product; those that were product led, such as the securing of raw materials supply and the optimization of the product; and those that were business led such as the development of marketing material.

The knowledge-based partner and particularly the academic staff involved, were expecting to enhance their research profile, build links with an industrial partner and obtain new, industrially relevant material to support teaching. There were two academic staff involved in the programme who had specialist expertise in different areas of chemistry.

The associate appointed was an organic chemist, who had recently completed PhD studies. KTPs are traditionally offered to graduates, but the scientific nature of this programme meant that the additional skills and knowledge of a more developed associate were beneficial. The associate was expected to develop management skills to obtain a level 4 NVQ in management. Further, they would benefit from a training budget, would obtain substantial commercial experience, as well as access to university facilities and training opportunities. In addition, they would also receive direct mentoring from both the academic supervisors and the company supervisor. The expectation was that the associate would develop scientifically, managerially and personally during the course of the programme and by its conclusion, would be operating as programme manager with a high level of independence and the potential to take a management role following programme completion.

2.2 Management of the Programme

In recent years, only 2-3% of KTP projects have been associated with Chemical Sciences Departments in Universities (Technology Strategy Board, 2008). The KTP between LJMU and Salt Union Ltd was a science-based programme, and incorporated a high proportion of investigative work.

The academic partners spent around 10% of their time working on the project, including meeting with the other partners on a regular basis to discuss progress. The KTP associate spent 80-90% of their time on work directly related to the project; the rest of the time was spent on tasks associated with the Company's activity and personal development. The day-to-day work of the associate was mentored by the industrial supervisor. The work programme was defined in advance with key deliverables identified. Progress was monitored via weekly and monthly meetings as well as formal reviews every four months in the presence of the KTP facilitator who represented the fund provider. Thus, the team had to provide evidence that the work programme was on target and that deliverables were being met. The Associate had little experience of project management and developed considerably in this area. The associate obtained both levels of the widely recognised Prince 2 project management course, and was able to apply this training to research management.

The work programme was extensive, covering a three-year period. A significant proportion of the work was investigative in nature and the outcomes could not be predicted. This required that subsequent items in the work plan were modified in the light of findings, or that further experiments had to be incorporated into the work plan in order to reach a clear scientific conclusion. Thus the programme team worked together to modify the work plan several times during its execution and this could be justified to the funding providers.

The programme was also influenced by commercial and business factors. Around 18 months into the programme, an alternative ABP had been identified and its potential was being assessed. However, due to market influences, the raw material cost increased significantly, and the product became unviable as an alternative on a cost-basis. Therefore the exploration into this raw material was suspended.

There were several changes affecting the programme team which did not arise from the work plan itself. There was some re-structuring within the company, at executive level, driven by changes in the parent company, Compass Minerals. Following promotion, the managing director moved from Salt Union, into a post within Compass Minerals, and a new manager appointed. The programme team had to work with the new manager to promote the benefits of the research and to disseminate its findings.

2.3 Assessment of the Programme

The outcomes of the project were reviewed every 4 months at the formal management meeting between the Managing Director, industrial supervisor, both academics and the Associate. This meeting was also attended by the KTP advisor from Momenta. The delivered objectives were assessed and those to be delivered during the next period identified. The expected tangible benefits to all parties were documented at the start of the programme, and these and any additional benefits recorded.

3 Results and Discussion

An important criterion for a successful KTP partnership is that all three parties benefit from the programme. The benefits for the company partner and associate are discussed below in Sections 3.1 and 3.2 respectively. The University involved in the programme has benefited significantly in a number of ways. This is discussed in terms of the knowledge based partner (Section 3.3) and the specific academic staff involved (Section 3.4). A further measure of the success of a knowledge transfer programme is to assess progress one year after its completion and this is outlined in Section 3.5.

3.1 Company Partner Development

The project was invaluable in establishing knowledge of ABPs within the company, making the company able to develop its products and make commercial decisions with autonomy. Technical knowledge and procedures were embedded within the culture of the company, as represented by the establishment of a research laboratory facility, and the establishment of a technical database containing procedures for testing and validation. At the end of the KTP, the company had the ability to test, optimize and validate new and existing products. The raw material supply was secured due to a new commercial agreement with the supplier which covered both the specification of the material and the cost, and represented a large cost saving. In addition to this the turnover of the premium product had increased, resulting in higher profits.

The research work on the de-icing ability, and corrosion inhibition ability of the treated salt product provided validation of the enhanced performance of the product, compared with standard rock salt, placing the company in a secure position with regard to its marketing claims. As a result new marketing brochures were produced to publicise the premium product to customers and users. More rigorous techniques for sampling and testing of both raw materials and finished products were introduced, and due to improvements in understanding of the product performance characteristics, manufacturing and storage conditions were optimised.

Table 1 Major Benefits for Company Partner

Outcomes	**Benefits**
Recruitment of trained manager	Knowledge of business and products
Research capability	Development of products
Better understanding of the product	Improved information to customer
Increased product sales	Increased profit margins

During the KTP programme, the associate undertook an investigation into existing patents regarding use of treated salt in de-icing. This investigation highlighted the large number of patents, and greatly increased the company's awareness and understanding of the Intellectual Property (IP) position. The associate was involved in the filing of a patent which was tangentially related to the project.

There has been knowledge transfer in other areas in addition to the chemical and research management outlined in the project proposal. The associate has been involved in safety management and served on the safety committee. A model for assessing risk, developed by the university was modified and adopted by the company. Consultation with an expert, from the university, on statistical analysis, improved experimental design and the interpretation of data.

At the end of the project, the US parent company appointed the associate as the Research & Development Manager responsible for product development within the highway de-icing unit. The work of the KTP programme, had raised the profile of treated salt within the company and the associate was expected to transfer the testing and validation procedures developed for the UK product to the range of materials used for de-icing in North America.

3.2 Associate Development

The KTP programme offers a unique training opportunity to the associate. The associate benefits from the experience gained from working within a commercial environment, and in this case, training in research methods, and the direct mentoring from an academic team. In addition there is a training budget which allows the associate to undertake a number of independent training courses, which together meant that the skill base was developed significantly over the duration of the programme. Courses covered project management, people management and creativity as well internal auditing.

This was a scientific work programme and the associate developed chemical knowledge and ability to manage research projects. In addition, due to the requirement of KTP procedures, skills were developed in chairing meetings, taking minutes, and delivering presentations to commercial meetings, skills not normally addressed in an academic research role. The associate also gained commercial experience of issues such as supply chain management, pricing strategies and marketing, as well as developing interpersonal skills by dealing directly with customers, suppliers, and interfacing with different levels of management within the UK and the parent company.

Table 2 Major Benefits for the Associate

Outcome	**Benefits**
Employment with the company partner	Management role within a profitable group of companies
Qualifications in management	Broader skill base
Industrial experience gained	Enhanced career opportunities
Networking opportunities	Increased knowledge and business opportunities

The programme allowed the associate to obtain a level 4 National Vocational Qualification in management (NVQ), and qualify as a Prince 2 practitioner in project management. There were academic opportunities such as lecturing to undergraduates, and acting as industrial supervisor to summer placement students (see Section 3.4.2) and commercial opportunities such as presenting at international exhibitions. Professionally, assessment has been conducted for the award of the Chartered Chemist status awarded by the Royal Society of Chemistry, with one of the academic partners acting as professional mentor.

3.3 Knowledge Base Partner Benefits

There is reasonable funding within the programme budget to purchase equipment for the project. This remains the property of the knowledge base partner after completion of the programme and has provided improvements in facilities for research and undergraduate projects (Table 3).

Table 3 Major Benefits for Knowledge Base Partner

Outcome	Benefits
Purchase of new equipment	Improved research facilities
Research income	Enhanced reputation in RAE
Staff training	Development of technical staff
First completed KTP in the school	Raised awareness of KTP

The Research Assessment Exercise (RAE) is a continuing hurdle for University departments in the UK. This assesses the quantity and standard of research within the department and, based on the rating, departments receive funding for research. In the 2008 Research Assessment Exercise, the monies to operate the KTP programme counted as research income generated by the school and this enhanced, the rating of the submission and thus the funding received as a result of the assessment exercise. The KTP programme was mentioned in the university submission as a new source of income for the academic school and this enhanced the individual submission of the academic staff. There is now improved awareness of KTP programmes within the academic school and this will encourage other academic staff to look for industrial partners.

One of the technical staff within the school has been trained in the use of high pressure liquid chromatography (hplc). This was important primarily to give dedicated technical support to the project, but it has also enhanced the technical skills of the school staff. The school operates several schemes to raise the profile of the chemical sciences and assist in recruitment of undergraduate students. The associate was able to take part in an outreach event intended to stimulate interest in chemistry at the school level. As the theme for the event was salt, the associate was able to show the industrial relevance of the chemistry investigations undertaken. Often, it is difficult for school children to see the industrial relevance of laboratory based chemical studies and the input from an industrial researcher was invaluable.

3.4 Academic Staff Development

3.4.1 Development of Research Profile

Several avenues of research have been identified as a result of the KTP work programme. The academic staff did not previously have formal research collaboration, but have now established a collaborative partnership. Research has been developed in a number of ways, including undergraduate projects and as a component of a post-graduate research programme. Three research publications are currently in preparation: two arising directly from the work defined under the KTP programme and one arising from additional projects.

A significant benefit to the research profile of the academic staff is that the funds awarded to the academic school as part of the KTP budget have been used to provide approximately 50% funding towards the cost of a PhD studentship which the academic staff now supervise jointly, thus continuing their newly established research partnership. It is worthy of note that it required all the staff development monies and most of the indirect costs to achieve this outcome.

The management skills of the academic staff have been developed during the course of the programme (Table 4). As the project required a team to work from locations that were 40 miles apart, selection of a suitable candidate was vital to the success of the project. Experience was gained in the selection and interview process, both in appointing the associate and, later, in selecting students for training placements. There was a requirement for the project to review the performance of the associate, so additional experience has been gained in conducting staff appraisals, an opportunity not normally open to academic staff unless in senior positions. In addition, the management of a senior research worker, required different skills and strategies to those used with undergraduate students, so management skills, team working and interpersonal skills were developed.

Table 4 Academic Benefits – Research and Personal Development

Outcome	**Benefits**
Fostered new research partnership	Developed academic knowledge in existing and new subject areas
Publications	Improved academic profile
Funding for PhD	Research development
Extension of programme to new areas of academic interest	Generates new ideas for research
Improved understanding of industry and intellectual property	Potential to engage with other knowledge transfer projects
Highly structured work programme	Ability to deliver results under pressure and to target deadlines
Experience appraisal/interviews	Develop management skills

Networking opportunities have arisen with other KTP industrial partners, companies and University departments during the project. This has the potential to establish new links that might lead to further research or consultancy opportunities.

3.4.2 Development of Teaching

Through working on the KTP programme, the academic staff were able to bring industrial relevance to their teaching in a number of ways (Table 5). For instance, a number of case studies were developed for use in the teaching of undergraduate modules. One such case study allowed undergraduate students to recognise the importance of developing oral presentation skills to enhance their employability and the other provided relevant industrial context to a laboratory assignment.

The associate was invited to make a contribution to undergraduate teaching by delivering a lecture on a research methods module. Due to their specialist expertise and knowledge as a PhD Chemist, it was possible to fill a knowledge gap left by the sabbatical of an academic colleague.

The company provided prizes for presentation to undergraduate students. This rewarded the best students for their performance and also helped to raise awareness of the company profile at a time when students were seeking employment.

Table 5 Academic Benefits – Teaching

Outcomes	**Benefits**
Case studies for undergraduate modules	Enhanced student experience with application based relevance
Contribution of Associate to teaching and outreach events	Provided industrial relevance to undergraduate teaching
Undergraduate prizes from Company Partner	Provides incentive and rewards for students
Industrially relevant projects	Enhanced learning experience
Undergraduate placements	Develops students' skills

A total of ten undergraduate projects were conducted and this helped to develop the research that has arisen from the main project (Table 5). The industrial context of the projects gave added value to the undergraduate learning experience. In particular, the students were able to see the commercial relevance of their project through meetings with the associate. The students were asked to present their results at these meetings and this tended to enhance their oral presentation skills. Typically, the students working on these projects made above average progress and performed very well at final assessment in their projects. Overall, these projects resulted in a high level of satisfaction and achievement for the students.

In addition to the undergraduate programme projects, a training placement with bursary was financed by the company partner and this provided the opportunity for a student who had completed the second year of undergraduate study to undertake a summer research project. There is a large gulf in going from an undergraduate degree to postgraduate research for most students. Thus, a summer placement provides an ideal opportunity for undergraduate students to gain training in research and help to assess aptitude for this type of work. It also develops organisational skills that are beneficial to performance in the final year research project.

As the summer placement was associated with the company partner, it was possible to give a high level of industrial relevance to the project. The students were able to gain experience of business meetings for the programme, a site visit to where the chemical production plant and the opportunity to present results to the company. Thus, the employability skills of the student were enhanced significantly during the project. Such skills are not easily obtained in undergraduate programmes.

These projects supported a larger research programme and allowed more progress made both in the undergraduate projects and the summer research placements due to efficiencies of knowledge. It also increases probability of undergraduate projects leading to journal publication.

3.5 One Year On

Following the formal close of the project, the knowledge base partner and company partner continued to work together. There was continuing chemical analysis work performed for the company, and an additional student summer placement financed, the results of which were presented to senior management and fed into the US sector of the company. Sales of treated salt in the UK market have continued to grow, rising from 14% [of total sales] in 2006/7 to 20% in the winter of 2008/9.

The former associate has now been made the Technical Development Manager for Compass Minerals Group, which incorporates Salt Union and five other subsidiary companies; in the UK, US and Canada. This new role includes identifying new markets as well as working with platform teams to drive new product development. They travel extensively, in the UK, the US and Canada, meeting customers, suppliers and attending conferences as well as providing technical support to sales teams. Further, they work closely with the Specialty Products platform team where he acts as the functional lead for technology. These direct contributions have helped lead to the successful launch of treated salt products by both US and Canadian companies into the market place. As comparison, of the KTP projects that were completed in 2008, 59% of associates continued into employment with the company (Technology Strategy Board, 2008).

In addition to this appointment, the Technology Group has seen a major investment in Human Resource with the appointment of a senior director, technical manager, and research and development chemist. Three new products have been brought to market in the US and other products are in the development stage.

The academic staff have further developed the research relationship established with the KTP programme. They now jointly supervise a post graduate research programme, and continue to stage schools liaison events, which are supported by Salt Union Ltd. Two further undergraduate projects have been conducted since the close of the programme and more work in this area is anticipated. The Lead Academic has been promoted to Subject Leader for Pharmaceutical & Chemical Sciences, a senior management role within the academic school.

4 Conclusions

The programme was successful in delivering its planned objectives, and was assessed at Grade B (very good) by the awarding body. Of the KTP projects that were completed in 2008, some 51% of them received a Grade B (Technology Strategy Board, 2008). Only 7% of the completed projects received Grade A (excellent). The 36 month programme for this KTP was finished after 29 months to allow the associate to be appointed as research manager, a measure of the successful knowledge transfer that took place. As a result of the KTP programme the Company has increased its profits, increased sales of the premium product, and established strength in product R&D.

The associate has gained experience and training which a purely academic post would not offer, and which would be difficult to obtain in a graduate position in an SME. This is reflected in the seniority of their current role.

The academic staff have developed new research collaboration, and enriched student learning opportunities in ways that are not possible during a standard undergraduate programme. Further, the academic staff were invited to present their experience to the University Board of Governors as an example of good practice in knowledge transfer. One year after the conclusion of the funded programme, all parties continue to benefit from the results of the KTP and anticipate further collaboration.

Acknowledgements. The authors would like to thank the UK Technology Strategy Board (*formerly DTI*) and Salt Union Ltd for the opportunity and funding (KTP Grant No: 0001057). Harold James, Kay Monaghan and Alan Sheen were all involved as contacts with Salt Union Ltd at various stages of the project. The Administrative Staff in the KTP unit at Liverpool John Moores University are thanked for their never-ending help and advice during the project.

References

DIUS, UK Government publication. Innovation Nation (2008), `http://www.dfes.gov.uk/hegateway/strategy/hestrategy/`

DfES, UK Government publication. The future of higher education (2003), `http://www.dfes.gov.uk/hegateway/strategy/hestrategy/`

Galbiati, M., Edmondson, D., Tochtermann, M., Vercesi, P., Dölp, U.: Industry and Higher Education, 15(3), 197–208 (2001)

Graca, M.: Industry and Higher Education, 19(5), 363–374 (2005)

Hofer, F., Holzer, F., Adametz, C.: Industry and Higher Education, 18(3), 177–186 (2001)

Salt Union Ltd., `http://www.saltunion.com/`

Technology Strategy Board, Knowledge Transfer Partnerships Annual Report2007/2008 (2008), `http://www.ktponline.org.uk/content/libraryMaterial/KTP_2007-08.pdf`

Valentin, E.M.M., Sanchez, J.J.N.: Industry and Higher Education, 16(1) 55–71 (2002)

Integrated Care e-Pathways Using Formic Fusion for Patients Undergoing Elective Hip and Knee Replacements

Mohammed Rizwan[1,*], Eileen Scott[2], and S. Maxwell[3]

[1] KTP Associate, Room D117, Ebsworth Building, School of Medicine and Health, Durham University, Stockton on Tees - TS17 6BH
e-mail: mohammed.rizwan@durham.ac.uk
[2] Post Doctoral Research Fellow, Room D117, Ebsworth Building, School of Medicine and Health, Durham University, Stockton on Tees - TS17 6BH
e-mail: eileen.scott@durham.ac.uk
[3] Director of Postgraduate Studies, Room E112, Wolfson Research Institute, School of Medicine and Health, Durham University, Stockton on Tees - TS17 6BH
e-mail: s.a.maxwell@durham.ac.uk

Abstract. The objective of this research is to re-engineer data capture and analyze process of orthopaedic patients, involving multidisciplinary & cross-departmental healthcare records towards a unified Integrated Care e-Pathway (eICP) information system. The project will introduce a homogeneous, consistent and efficient way of capturing and querying of orthopaedic surgical patients' data across the relevant hospital departments and will complement other NHS (National Health Service)-wide initiatives on electronic health records. The chosen approach is a mix of intelligent re-designs of paper based pathways with an Optical-Character-Recognition (OCR) process via Formic Fusion Software, and a successive move towards routine electronic data capture which will be fully integrated with other hospital-based systems. Reports will be generated using Statistical Process Control (SPC) tools. So, it is a huge change management project involving culture change. A survey is conducted to study the attitude of clinical staff and service users towards implementing technology at the point of care (before and after implementing new technology). It also involves adopting lean principles which is termed as North East Transformation System (NETS). The research tracks the current status of National Program for IT (NPfIT), run by Connecting for Health (CfH).

Keywords: Integrated Care e-Pathway, Formic Fusion Software, Culture Change, SPC, NETS, NPfIT.

---

* Project Lead (Electronic Pathways), North Tees and Hartlepool NHS Foundation Trust, Health Information Department, Hart Building, University Hospital of Hartlepool, North Tees & Hartlepool NHS Foundation Trust, Holdforth Road, Hartlepool – TS24 9AH.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 91–97.
springerlink.com

1 Introduction

An integrated care pathway (ICP) is a method for the patient care management of a well defined group of patients during a well defined period of time[1]. Basically it is the patient's journey at every stage of care in a secondary care setting (in the current context). The research is based at the North Tees and Hartlepool NHS Foundation Trust.

The objective of this paper is to create electronic care pathways (with formic fusion) using the current paper based ones as a starting point. These paper based forms later on can be replaced with fully integrated electronic version of pathways. Reports can be generated with a click of button and this reduces the process of going through clinical audit department. These reports can be generated using Statistical Process Control methods.

The Japanese adopted a principle called Lean towards quality improvement by removal of waste. This was implemented in the Toyota car manufacturing company. Later on many organisations implemented lean principles as quality improvement techniques. Virginia Mason Hospitals in United States pioneered this within the healthcare sector. The North East Strategic Health Authority (SHA) is one of seven 'Pathfinder' organisations implementing NETS (North East Transformation System) across the north east[2]. They adopted Virginia Mason's lean concept as a quality improvement tool in the healthcare sector along with seven pathfinder organizations in North East of England. These seven pathfinders are as follows:

- County Durham PCT (Primary Care Trust)
- NHS South of Tyne and Wear - Sunderland Teaching Primary Care Trust, South Tyneside PCT and Gateshead PCT
- Gateshead Health NHS Foundation Trust
- *North Tees and Hartlepool NHS Foundation Trust*
- Northumberland, Tyne and Wear NHS Trust
- Tees, Esk and Wear Valleys NHS Foundation Trust

Part of NETS's objective is also to produce systematic improvements to the Care pathway, which fits with the objectives of this project[2]. A *culture change* towards electronic workflows should originate in clinical teams (who perform the data input now on paper) rather than from IT (Information Technology) teams who are committed to electronic data capture but may not be completely aware of the operational needs of the clinicians or clinical practice. Culture change is a major challenge in implementing electronic pathways with or without lean principles. This project will develop systems that can be rolled out across the hospital for real time data capture meeting various business needs (like payment by results, commissioning etc.,) and providing quality care.

3 Methodology

Knowledge transfer from the Wolfson Research Institute, School of Medicine and Health, Durham University, will relate to the process of redesigning the ICPs from a clinical perspective with a view to IT enabling the real time data capture. The Business School, Durham University, will contribute to the deployment of a fully functioning information systems prototype which includes effective use and integration of software available at the Trust. Barriers to near-patient electronic data capture will be investigated using health science research methods (questionnaires, structured and semi structured interviews, focus groups, discourse analysis) so that culture change can be initiated; data collection procedures will be re-engineered, and automated transfer to electronic patient records developed and implemented. The application of industrial quality control methods to healthcare and automated reporting and regular clinical review of collected data will ensure that appropriate patient-specific action is taken as necessary. These methods will include process mapping, development of standard operating procedures for clinicians as well as statistical process control and automated reporting of Key Performance Indicators (KPI).

The major task is to construct integrated care e-pathways replacing the current paper based pathways. ICPs are designed to suit all clinical and administrative criteria and have the capability of communicating with Electronic Health Record (EHR). The objective will remain to provide quality care when patients move through different stages of pathways.

The project has been divided into the following phases

Stage one

Introduction to Integrated Care e-Pathways - Design an overall project plan using Gantt charts, identify critical path and make a risk analysis.

Stage two

It includes interaction with a multi-disciplinary project team; understanding of data confidentiality and data protection; working (training) on project relevant softwares like Formic Fusion, SQL server, Biztalk etc; Discussion on national IT developments in the NHS, particularly National Program for IT (NPfIT) and Connecting for Health (CfH) and understanding the need for compatibility with these at a local level. Key Performance Indicators are recognized. Literature search is also initiated.

Stage three

Survey the attitude of medical staff to the existing ICPs for hip and knee replacements - Current pathways are improved by mapping processes using Microsoft Visio. The opinion of ICP users (staff) is surveyed by questionnaires / structured interviews to assess their attitude for potential analysis on Formic Fusion. This survey has dual function as it investigates the current culture but also attempts to generate positive future expectations of the new e-care pathway system. They are also influenced in such a way (either by online sessions or videos) that they will adapt themselves to culture change of new technology.

Currently, we are in the process of getting Ethical Approval to conduct Focus Groups and One-to-One Semi-Structured Interviews for Staff and Service Users of North Tees and Hartlepool NHS Foundation Trust (Ethical Approval has been granted from School of Medicine and Health, Durham University). From this study we also believe that we can come to those big challenging questions, which we feel are preventing staff from adopting new technologies. We can also study why these perceptions and insecurities are developed in the mindset of service users towards EPRs. This will enhance our understanding of change management and open the doors for tackling these changes when implementing a new technology in the healthcare sector.

Stage four

Review current ICP and re-design - The aim here is to reduce the size of the ICP to essential or critical fields which are more likely to be completed in full. Datasets of integrated care pathways are revised and superfluous fields removed, core data availability identified, future data and reporting requirements identified, SPC (Statistical Process Control) methods identified. A detailed research will be conducted on how to apply Lean business processes principles within the proposed ICP project. Lean also becomes a part of North East Transformation System (NETS), which is based on the principles of lean management (improving quality by removing waste).

Stage five

Develop, pilot and roll out a paper based data collection system - Paper forms (for hip and knee replacements) are created on Formic for electronic data capture and a standardized scanning process is implemented. Data Capture is done using various data capturing objects (Figure 1) available within Formic Fusion software. Briefing materials on the paper-based system for use with the multidisciplinary team are developed. Paper based forms are then used to assure the Optical Character Recognition (OCR) process. This paper system will be replicated electronically and data will be scanned step by step, as stated above.

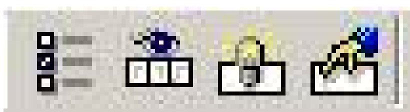


Fig. 1 Data Capturing Objects (Left to Right: Tick box Group, Handwriting Recognition Object, Manual Image Area, Automatic Image Area). *Source: Formic Fusion Software*

Stage six

Develop and test the central database and exchange issues with existing data sources – By now database should have been ready. So, database protocols are created, database tested, standard reports are created and online help system created. KPI dashboards (Data mining techniques, MS Sharepoint, reporting services etc,) will be deployed at this stage.

Stage seven

Roll out electronic data capture, reporting and use of the database - Formic Fusion is used to convert paper forms to electronic forms. Test data input using electronic forms on the agreed input devices (personal digital assistant). Training materials will be developed and also team will be trained on electronic data capture.

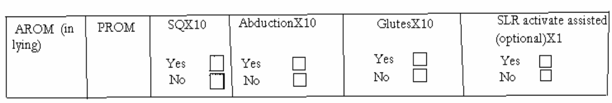
Stage eight
Project Closure
We have adopted different pragmatic research methods for different activities (eg, Focus groups and Interviews to learn attitudes and perceptions of staff and service users). We will also conduct Rapid Improvement Work Shops (as a tool for NETS) for training staff and helping them using the new e-pathway.

4 Discussion and Conclusion

Integrated Clinical e-Pathway is an intensive field and poses challenges especially with respect to culture change. So ICPs are created by involving various members of multidisciplinary team in its design by means of training, surveys and meetings. During this process, they might overcome some aspect of huge culture change before the actual implementation. Our objective will still remain to deliver better patient care and design ICPs in a convenient and timely fashion.

Formic Fusion is being used in the Trust on a variety of administrative initiatives but its application within the medical treatment process and use by clinicians has not been tried before. This pilot phase of testing paper forms created in Formic Fusion is therefore critical to the success of the project as it will familiarise the clinicians with the concepts before they move to direct input.

We have currently designed (new) and re-engineered (already existing) pathways to create new Formic forms. These are in the process of approval before being implemented (electronically). The author would like to present current pathway design with a very small example. Figure 2 depicts the conventional Physiotherapy ICP for post-operative hip replacement exercises. The Physiotherapists use 5 different sheets for different exercises to be done on 5 consecutive days. Figure 3 (redesigned ICP) represents the alignment of these exercises together instead of representing them on 5 different papers.



AROM (in lying)	PROM	SQX10	AbductionX10	GlutesX10	SLR activate assisted (optional)X1
		Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

Fig. 2 Conventional Physiotherapy ICP showing different exercises to be performed each day

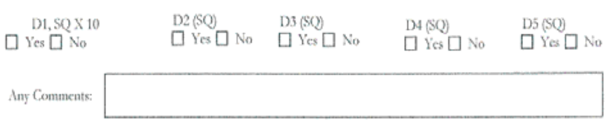


Fig. 3 Formic designed ICP showing each exercise to be performed for 5 consecutive days

Further, there is no scope to miss any patient information as everything is placed in one sheet and available electronically. Thus it gives a Lean look to the newly designed pathways. It also helps with the proper data analysis (and data management) as data is clustered together instead of being scattered on 5 different pages.

At the moment, we have also done adequate literature research and collected relevant content. As said earlier, whatever is learnt from the current work might be used to improve quality care across the current, local and national wide trusts. But our immediate objective is to design these e-pathways that are structured meaningfully and able to integrate with other hospital information systems available. There is also a potential to integrate these structures e-pathways with patient electronic health records, also meeting with the national targets (NPfIT).

There are no published articles on the current research area. Thus, it is a very good opportunity to conduct research (Confirmed with Formic fusion and www.library.nhs.uk/Default.aspx) in designing and implementing electronic pathways using formic fusion. It brings value to research conducted by Durham University at North Tees and Hartlepool NHS Foundation trust as a KTP (Knowledge Transfer Partnership) Associate.

To conclude, the following are the expected outcomes of implementing ICPs successfully with this KTP program:

- A new coherent, integrated medical electronic record of the entire treatment pathway based on a new scan-able paper based form & an exactly mirrored web-based electronic form. Acceptance of this by staff will be a major culture change for the Trust.
- Improved and shorter treatments for patients due to complete medical records being available and automated analysis for all clinical information.
- Improvement action plans based on a variety of electronic records as an ongoing process.
- Phased introduction of efficient procedures and systems for monitoring care pathways starting with paper-based systems/scanning moving to direct input via new Web based Information and Communication Technology (ICT) systems as a matter of routine.
- There will be no need for an intensive preparation of audits – electronic records are available ad-hoc on request. Cost savings in audit processes[3] can be achieved in real time
- Ability to demonstrate quality of care provision, including reducing waiting times, in an increasingly competitive market. This can be achieved by the *Pull* effect (lean principle), streamlining the process and reducing duplication of work.
- Change management and staff development of nurses as a catalyst for change leading to improved staff morale. This will be a challenge and a learning experience too.
- Closer links with the Wolfson Research Institute (Queen's campus) and the Business School (Durham campus) at Durham University.

This will also give an opportunity to set up similar pathways in other parts (trauma and spinal pathways) of the patient journey for any treatment within the current trust.

References

1. De Bleser, L., Depreitere, R., De Waele, K., Vanhaecht, K., Vlayen, J., Sermeus, W.: Defining Pathways. Journal of Nursing Management 14, 553–563 (2006)
2. North East (Updated 2008), North East Transformation System (Updated 2008), `http://www.northeast.nhs.uk/vision/nets/` Annual Report (2007/2008) (Accessed on February 12, 2009); North East Transformation System, `http://www.northeast.nhs.uk/_assets/media/pdf/NESHA_Annual_Report_07-08_final_sigs.pdf` (Accessed on February 12, 2009)
3. Sweeney, A.B., Flora, H.S., Chaloner, E.J., Buckland, J., Morrice, C., Barker, S.G.E.: Integrated care pathways for vascular surgery: an analysis of the first 18 months. Postgraduate Medical Journal 78, 175–177 (2002)

Abbreviations

Connecting for Health (CfH)
Electronic Health Record (EHR)
Information and Communication Technology (ICT)
Information Technology (IT)
Integrated Care e-Pathway (eICP)
Integrated Care Pathway (ICP)
Key Performance Indicators (KPI)
Knowledge Transfer Partnership (KTP)
National Health Service (NHS)
National Program for IT (NPfIT)
North East Transformation System (NETS)
Optical-Character-Recognition (OCR)
Primary Care Trust (PCT)
Statistical Process Control (SPC)
Strategic Health Authority (SHA)

The Virtual Engineer

Farshad Fahimi and David Brown

Portsmouth University
e-mail: josh.fahimi@port.ac.uk

Abstract. The complete implementation of the method presented in this text is filed in Patent 0921900.7. This paper proposes a novel approach to the motor fault diagnosis by applying a similar approach to engineer experts using feature fusion with the main aim of improving the performance and reliability of clustering and identification of the fault patterns. In addition, the significance of individual feature sets in specific fault scenarios, which is normally gained by engineers through experience, is investigated by using flexible Non-Gaussian modeling of the historical data. Furthermore the comparison is made by applying individual and fusion of feature sets to the probabilistic distributions of trained models using a Maximum a Priori (MAP) approach. To carry out the task, current waveforms are collected non-invasively from three-phase DC motors. Waveforms are then compressed into time, frequency and wavelet feature sets to form the input to the clustering algorithm. The result demonstrates the suitability of specific feature sets in different motor modes and the efficiency of fusion which is carried out with a Winner Takes All (WTA) approach.

1 Introduction

Manufacturing industries in the Britain exist within the global economy and their long-term viability depends on their ability to compete in the global market. To remain competitive in this environment manufacturing companies, particularly those in the traditional manufacturing sectors, must find new ways to reduce costs and increase production rates.

Many of the largest manufacturers have already addressed the cost issues by simply relocating their manufacturing facilities to emerging nations such as China, India and South America, where labour and energy costs are significantly lower than within Britain and the European Union; others have tried to cut their wages bill by reducing the numbers of expensive skilled engineers that they employ. Over time this last item has had a cumulative effect, so that it has become increasingly common for European product manufacturing companies to employ no skilled engineers at all. Maintenance is now routinely outsourced to specialist firms.

The falling demand for skilled engineering graduates has caused a decline in the number of universities offering engineering courses. Now the lack of graduate

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 99–108.
springerlink.com

engineers is itself a problem, particularly within the traditional disciplines of mechanical, electrical and control systems engineering. This makes essential contract engineering and maintenance services more expensive and difficult to source than ever before, and it places a disproportionately heavy burden on small to medium-sized manufacturers who cannot achieve the economies of scale made by the larger companies and who can ill-afford the increasing cost. Another problem for EU manufacturers is the cost of energy.

Manufacturing, by its very nature, is an energy-intensive industry and energy costs are often the single largest controllable operating expense in the manufacturing process. High energy usage is not only expensive; it adversely affects the environmental sustainability of the process itself. As green issues increase in importance, public opinion is turning against those industries which are seen to be wasting energy resources. It is essential that machinery is correctly operated and maintained if optimum efficiency levels are to be achieved but this requires a skilled workforce.

At the same time, the pressure to continually increase production rates is placing increasing demands on manufacturing machinery. Machinery is expected to operate at higher speeds and for longer with fewer scheduled downtime periods for maintenance. These demands, combined with a lack of in-house skilled maintenance staff, have made machine maintenance problems a key issue in European manufacturing. In many highly-automated factories, unscheduled downtime due to machine failure is the biggest problem facing plant managers and this, along with the associated problems of increased scrap production, directly increase costs.

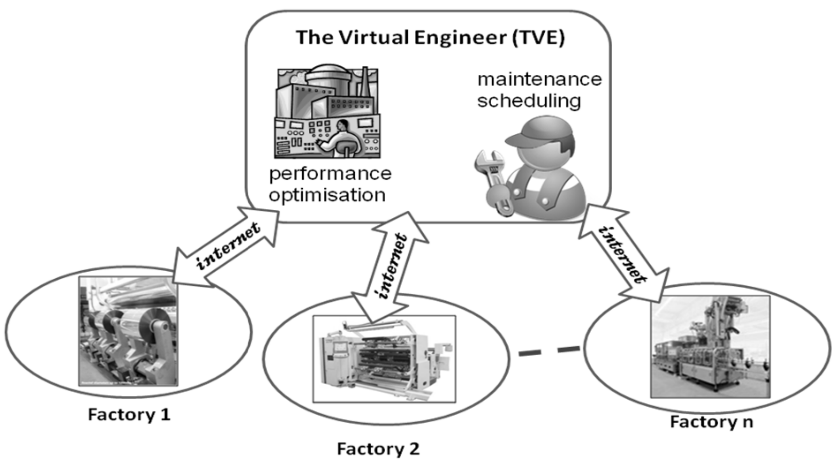


Fig. 1 Virtual Engineer is able to capture the data from the network and provide stable diagnostics

So these are the dilemmas faced by manufacturers in the EU. They are under pressure to decrease costs but this means investing in increasingly complex and expensive machinery. They need skilled engineers to maintain this machinery but these engineers are expensive to employ and difficult to find. Customers want more products at lower prices but manufacturers are finding it increasingly difficult to meet these demands, especially the SMEs who cannot achieve the economies of scale made by the larger companies. Consequently, EU manufacturers are increasingly losing business to non-European manufacturers in countries where engineers are plentiful, labour costs are low and climate change is not seen as an issue. If manufacturing is to survive in Europe and America, we must find a way to compensate for this lost engineering skills base and at a cost that struggling SMEs in particular are able to afford.

1.1 Re-establishing Competitiveness

To address these problems, our aims is to investigate and develop a low-cost means of providing expert engineering support to manufacturers, in particular SMEs who make up the vast majority of manufacturers within the Britain.

It is our intention to implement an Artificial Intelligence (AI) system that can simultaneously provide high-level engineering expertise to multiple production installations across multiple market sectors. It will enable machines to self-diagnose and self-optimise their performance by monitoring their operation, identifying and predicting changes in their performance, interpreting the meaning of those changes in real-terms that can be understood by low-skilled machine operators, and compensating for the changes to sustain optimum production performance and optimum energy utilisation. This system will be called **The Virtual Engineer (TVE)** (*Figure 1*).

TVE is designed to collect the knowledge of highly-skilled engineers and utilise it to enable low-skilled operators to operate and maintain their machinery with maximum efficiency. The immediate output of this project will enable manufacturers to:

1. Increase machine operating speeds
2. Increase machine utilisation time
3. Maximise the energy efficiency of the machine
4. Improve product quality by sustaining optimum machine setups
5. Reduce scrap product production.

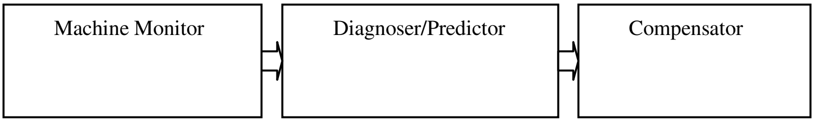
This will provide for them with a significant advantage when competing with low-cost non-British and non-European manufacturers in the global market.

This paper will provide results from an actual machine system showing the effectiveness of the Algorithms for predicting faults.

The effective collaboration between industry and the University via a KTP scheme and ongoing research will be highlighted.

2 Fault Diagnosis Framework

Fault diagnosis of industrial machinery can be envisaged as consisting of three parts: Machine Monitor, Diagnoser/Predictor and Compensator.



2.1 *Machine Monitor*

The Machine Monitor consists of an array of sensors mounted on the machine that are used to monitor its performance. Typically these could include current and vibration sensors, strain gauges, thermocouples, encoders, and other industrial sensing devices. In this paper only the current signal is used. This is a common sensor in machinery and therefore has significance in the development of a common platform for motor diagnostics.

2.2 *Diagnoser/Predictor*

The Diagnoser/Predictor is an Artificial Intelligence (AI) algorithm which analyses the data collected by the Machine Monitor and employs software technologies to identify patterns and trends in the data. This is the focus of this research. The basic Predictor/Diagnoser module's functionality can be divided into 3 stages of Feature extraction, Clustering and Compensator. Supervised clustering is used initially to model the clusters of data in training. This can be achieved by deliberately inducing faults and trends in the machines' performance, or by monitoring and logging naturally occurring trends and events.

1. Feature Extraction

The data collected from high-speed machine components such as motors is high density. Feature extraction reduces the density to a number of suitable points, called features or indicators. This has two main advantages: firstly, it provides the basis for the real-time, computationally efficient algorithm; secondly, it captures the necessary characteristics of the data and removes redundancy. In addition, a correctly configured feature extraction algorithm results in noise reduction. The number of features used depends on the number of sensors and the resolution of windows in a specific domain, as well as other parameters such as wavelet depth and frequency response analysis.

2. Clustering

In order to detect the faults or modes of the machinery, it is necessary to first model the data in each mode. Normally clustering allows the data to be modelled by statistical characteristics. So for training, the data is collected in different modes of machine operation and features are extracted for specific window sizes. Finally, the feature space corresponding to each dataset is calculated. In testing, the features are extracted from the window frame and probabilities are calculated using the modelled distributions. The probabilities indicate the likelihood of machine performance deviations in different modes using different features/indicators.

3. Compensator

The Compensator is not a part of this research and is mentioned merely for completeness. The compensator tunes the operation of the machine's control system to correct the performance deviations identified by the Diagnoser. The Compensator also feeds information into the maintenance system to ensure early-stage machine faults are corrected in time, before impacting on product quality or machine performance.

3 Initial Chart Analysis

Artificial Intelligence (AI) methods often aim at understanding the patterns in data by ignoring the underlying system parameters. However in the context of fault diagnosis, it is necessary to understand the charts in order to determine suitable feature extraction and classification methods to more efficiently flag the modes of the motor to the operators. In the experiments carried out in this paper four types of faults are considered: Overload (OF), Disconnection of Phase 1 (DPH1), Disconnection of Phase 2 (DPH2) and Disconnection of Phase 3 (DPH3) faults. These four faults and the normal (NF) working mode of the motor are the five modes considered as the objective for the pattern recognition methods described here.

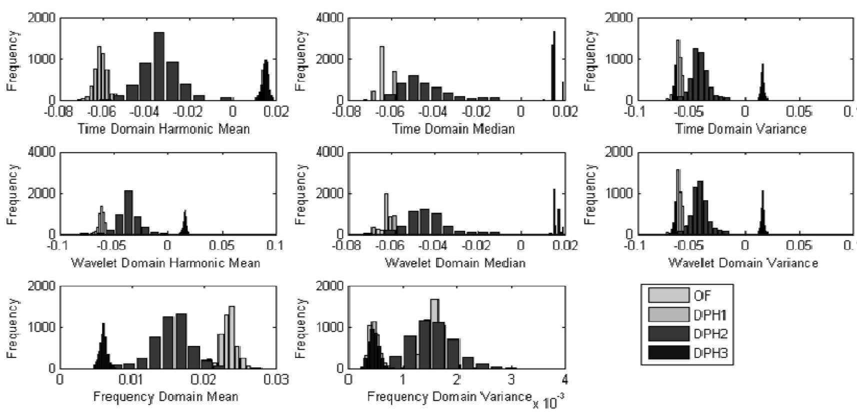


Fig. 2 Histogram models are each mode of the DC motor is measured by inducing the faults in the machine and recording the data

The analysis of the current signal shows that the change in shape and characteristics are unique to fault signals. For example, the frequency of peaks in data, and the minimum and maximum values in the current signal, change and these novel features are useful for identifying fault patterns. In AI, the process of extracting these novelties is called feature extraction. In industry, these features are more often known as indicators. An engineer/expert knows the importance of different sets of features in each scenario based on experience. The expert can identify the faults by looking at only a specific set of features/indicators which are significant to the specific mode of the motor. It is the aim of this paper to identify three main sets of features from two perspectives:

1. Accuracy: This is the percentage by which the faults are identified correctly by keeping the same classification method and changing the feature set of the current signal.
2. Misclassification Rate: Investigating how efficiently each feature set helps the classification task and what confusions are more likely to occur between faults.

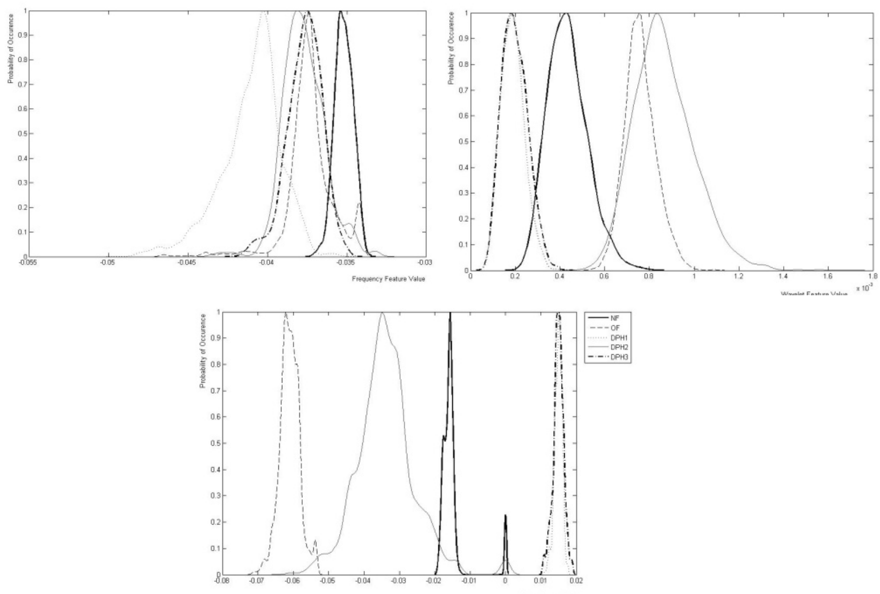


Fig. 3 The distributions are calculated by fitting the smoothing function over the mode histograms

4 Experiments

4.1 Data Collection

The data used for experiments in this paper is captured from a 3-phase brushless motor installed in the IIR[1] lab facilities. In order to be able to examine the efficiency of feature extraction methods in motor fault scenarios, four faults are induced and simulated, namely overload and disconnection of each of the phases (three phases in total). Initially any divergence from the normal mode of the motor is detected using clustering algorithms. The results following this section demonstrate the accuracy of detecting each fault as well as the misclassification rate.

4.2 Data Preparation

The data collected from the motor is raw. In order to extract the fault patterns in the wave forms which are suitable for identification task, and to also reduce the noise, data is compressed into three feature sets; time, frequency and wavelet. Time domain is used in the majority of research papers [4] due to its availability and simplicity. For example, the easiest form of fault diagnosis is based on thresholding the time domain values using fuses.

Frequency [5] and wavelet analysis are mostly favored because of their filtering abilities. One of the common problems in motor drive application is the presence of noise which corrupts the sensor reading. One solution would be to use low-pass filters. But low-pass frequency filters are inefficient in scenarios where information contains high frequency characteristics. That is where wavelet transform is most effective [3]. However the initial chart analysis shows that in different fault scenarios and datasets, the transformations behave differently and this provides novel representation useful for the task of identification.

4.3 Feature Extraction

The features are compared in three domains; time domain, wavelet domain and frequency domain. In order to do this, the statistical parameters of each domain are injected into the expert clustering method. The expert system learns the patterns by looking at the shape of histograms in historical information and records the states for each mode of the system. Training is carried out on 66,900 data points and the histogram results are shown in *Figure 2*.

Three types of features are implemented and compared for the purpose of this text. Time domain features (f_t) are the features extracted from a specific window size of current signal, in time domain. Wavelet domain features (f_w) and Frequency domain features (f_f) are features of wavelet and frequency domain

[1] Institute of Industrial Research, University of Portsmouth.

respectively. The conversion of these features into Feature Space (*FS*) format prepares them for subsequent Diagnoser clustering. To carry out this task, firstly the state space of the signals in all modes/faults are modeled, f_{all} is the representation of all features in the training data in matrix form as in Equation 1:

$$f_{all} = [f_t \quad f_w \quad f_f] \tag{1}$$

The linear expert system states are then defined by dividing the feature space into equal sized ranges, e.g. for the n^{th} feature (f_n):

$$\Delta f_n = \frac{max(f_n) - min\,(f_n)}{c} \tag{2}$$

In Equation 2, *c* is the number of slices in the training data Feature Space which is identifying of the resolution of training. The Feature Space (*FS*) for the n^{th} feature is defined in Equation 3 as follows:

$$S(f_n) = argmin_k(f_n - (min(f_n) + k\Delta f_n)) \tag{3}$$

The *FS* for the whole dataset is then calculated by going through the list of features relating to each mode and assigning them to the nearest slice number (S). This provides the basic model for the clustering experiment detailed in the next section.

Histogram distributions of data have been used in fault diagnosis literature such as [7]. As can be seen *Figure 3*, the distribution of data in different modes of the motor cannot be compared until normalized, due to the datasets having different sizes. Since the distribution is a representative of the probability of occurrence at each FS point, the normalization is carried out as below:

$$N(D_{mode}) = \frac{D_{mode}}{max\,(D_{mode})} \tag{4}$$

D_{mode} is the histogram distribution of a specific mode/fault of the motor where range scaling is applied and N is the symbolic form of normalized histograms.

4.4 Distribution Models

The training, as mentioned in previous sections, is carried out by firstly extracting the features and generating relevant histograms for specific mode of the motor. The final output provides the probabilistic distributions for evaluation of the confidence in the mode of the motor as can be seen in *Figure* 3. The smoothing technique used in this paper is taken from [6].

4.5 Probabilistic Non-gaussian Clustering

As can be seen in *Figure 3*, the distributions calculated from the previous steps are non-Gaussian and therefore cannot be represented using standard distribution models. To perform the clustering on the test data, two steps are necessary. First, the features from the current window frame of data must be calculated. The features are then used as input to distributions, where the probabilities for each mode are calculated using each feature space modeled distribution. Finally a Winner Takes All (WTA) competitive approach is used as a base for clustering.

The fault that is most frequently diagnosed by distribution models is selected as the strongest representative of the mode of the motor. The results from the clustering and feature extraction algorithms are divided into two main streams: Firstly, accuracy which is judged by comparing this system data with data generated by simulation of faults in a brushless three-phase DC motor. Secondly is the confusion matrix that demonstrates level of confusion between faults.

5 Results

For a more detailed version of this paper including the technical results please contact the author or Institute of Industrial Research (IIR), University of Portsmouth.

6 Conclusion

The paper has detailed a novel look at feature selection and fusion methods in fault diagnosis. Having investigated and understood the suitability of different feature sets in different modes of a DC motor the improvements on the fusion of these sets are presented. For the experiments a classification method based on histogram model fitting and Maximum a Priori (MAP) is presented. This is used as the common classification method to the current wave form and is non-invasively collected from sensor of the 3-phase brushless DC motor interface board. The feature extraction methods are then used to compress the wave form into time, frequency and wavelet statistical feature sets. The results from the experiment section show the suitability of different feature sets by comparison between classification accuracy. This is similar to an engineer looking at different indicators while diagnosing the machines. The results shows that a mixture of feature sets can increase the efficiency of the fault diagnosis. Therefore a WTA approach is used to compare the mixture of feature sets to the individual sets and provide the results. The result of the fusion shows an improvement to the individual use of feature sets.

References

[1] Lu, B., Gungor, V.C.: Online and Remote Motor Energy Monitoring and Fault Diagnostics Using Wireless Sensor Networks. IEEE Transactions on Industrial Electronics 56(11), 4651–4659 (2009)

[2] Lawrie, R.J.: Electric Motor Manual: Application, Installation, Maintenance, Troubleshooting. In: Lawrie, R.J. (ed.). McGraw-Hill Companies, New York (1987)

[3] Giaouris, D., Finch, J.W.: Denoising Using Wavelets on Electric Drive Applications. Electric Power Systems Research 78(4), 559–565 (2008)

[4] Gao, X.Z., Ovaska, S.J.: Soft Computing Methods in Motor Fault Diagnosis. Applied Soft Computing 1, 73–81 (2001)

[5] Çalışand, H., Çakır, A.: Rotor Bar Fault Diagnosis in Three Phase Induction Motors by Monitoring Fluctuations of Motor Current Zero Crossing Instants. Electric Power Systems Research 77(5-6), 385–392 (2007)

[6] Bowman, A.W., Azzalini, A.: Applied Smoothing Techniques for Data Analysis. Oxford University Press, Oxford (1997)

[7] van Wyk, B.J., van Wyk, M.A., Qi, G.: Difference Histograms: A New Tool for Time Series Analysis Applied to Bearing Fault Diagnosis. Pattern Recognition Letters 30(6), 595–599 (2009)

Store POINT: Revolutionising Art Work Production

Mark Alford[2], Mary E. Thomson[1], Richard Thompson[2], and Rick Z. Xu[2]

[1] Faculty of Computing, Information Systems & Mathematics,
Kingston University, Kingston-upon-Thames, Surrey,
KT1 2EE, United Kingdom
e-mail: m.e.thomson@kingston.ac.uk
[2] StorePOINT International Ltd, Hampton Wick, Kingston-upon-Thames,
Surrey, KT1 2EE, United Kingdom

Abstract. This paper describes an innovative system to automate the workflow for translation of artwork text, developed through a KTP partnership between Kingston University and StorePOINT International Ltd, an artwork automation and localisation company situated in Hampton Wick. The 'POINTandGo! Localise' system is a web-based application available to managers, clients, artwork developers and translators for document and graphic artwork translation/trans-creation. It has already produced significant savings in cost and time through the automation of the workflow process and the use of translation memory whilst improving the quality of the final piece. But it is the use of contextual translation memory which is unique to this system that has the potential to revolutionise the way in which artwork produced in multiple languages is produced in the future. The project is an example of how vision and ideas from the business partner have come together with skills from the University and KTP Associate to create an interesting and unique product that will not only bring added value to the company but also to the whole area of artwork production.

1 Introduction

StorePOINT International Ltd is an artwork automation and localisation company based in Hampton Wick. It started life as a pre-press production company and built systems to automate the artwork of catalogues and magazine spreads. The efficiency produced by this automation led the company to offer the systems to its clients hence the description 'an artwork automation' company. A growing client base and increasing demand to produce the same artwork in multiple languages led to the idea of developing a POINTandGo! Localise (PAGL) system to incorporate translation into the automation process, working in partnership with Kingston University through a Knowledge Transfer Partnership (KTP).

This paper starts with a brief look at some basic concepts on which PAGL is based before examining what PAGL is all about and how it works. The concept of contextual translation memory and its contribution to PAGL is considered

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 109–114.
springerlink.com

separately given its importance to the whole development. With an understanding of what the system is all about, some technical aspects are considered and then future work is discussed before drawing conclusions.

2 Workflow Systems

Business processes have a high dependency on the flow of documentation and commonly it is the documents that accompany the process that become the key factor between the success or failure of the business process. Keeping control of document progress within a process is critical but often challenging. In the past few years, the automation of workflows has received a lot of attention from industry and academia with a view to improving the tracking of documents through the whole process whether it is in a scientific or engineering context or in business. Automating the workflow process involves creating a system that tracks the progress of process so, that at any one point in time, the user can determine where the process is and any constraints in the way of that process. The 'automation' factor is the use of a computer system to record the progress of the process together with the people involved.

PAGL is a work group distributive system, which uses the concept of 'hub and spoke' working. 'Hub and spoke' working is an approach used by airlines to manage complex routes. It is based on the concept of a bicycle wheel that has a central hub and many spokes. Airlines route their fights from a central hub to many destinations (the spokes) and back rather than creating a spaghetti type network of flights between destinations. This may not be a convenient routing from a passenger's perspective but the big advantage of routing all flights through a central hub is that it makes the overall system more efficient through centralized control and management. StorePOINT is not the first business to adopt a 'hub and spoke' framework. The concept has grown in application over the years and can be seen in a number of areas such as finance, investment and healthcare. However, it is a framework that naturally suits what StorePOINT wanted to do with its automation system.

3 The POINT and Go! Localise (PAGL) System

Targeted at a niche market and developed as a web-based application solution to trans-creation workflow, PAGL is an enterprise wide internationalisation tool for document and graphic artwork translation/trans-creation. It uses online database publishing systems, based on and around QuarkXPress (the industry standard page make-up software package) and InDesign file formats, integrated with Microsoft Office applications. It allows authors, editors, translators and creative writers to work over a web based interface with the original document or artwork via a web browser, controls origination of text and builds translated versions, text and image from and into any document as a real time page building process.

In a little more detail, the system can be split into two stages:

Stage 1: Translate

- the artwork is commissioned and the artwork developer produces the master artwork in the form of a Quark/InDesign document
- the client approves this and loads it onto the system
- the client then tenders the translation tasks to agencies or translators/proof readers with the desired languages and deadlines
- agencies or translators are shortlisted on skills, rates, availability and ratings
- the tasks are then assigned to one or more of the shortlisted agencies or translators with deadlines

Stage 2: The Finishing Stage

- proof readers proofread the tasks after translators complete the translation and may refer it back to the translator
- the artwork is polished and any necessary manual adjustment is made to the language formatting
- the client and the task manager approve the artwork or request changes
- the artwork receives final approval and goes into production

Control of the whole process is managed through automated emails that notify the relevant parties when a step in the process has been completed. This enables the client to track progress of the artwork. The translator is given the option of working offline with a Rich Text Format (RTF) document or online with the original artwork being updated via the Browser they use - Internet Explorer, FireFox or Safari. In either case, the translator is able to load his work into the original artwork to preview the effects of the translation on the artwork itself and introduce a quality aspect to the process that was not previously possible.

This automation made it possible to produce and approve artwork quickly, but as the translation aspect of the work increased, the company realised there was an opportunity to gain a further competitive edge through the use of translation memory.

4 Contextual Translation Memory

Translation memory is essentially a database that stores the words, phrases and paragraphs that have been translated with the source text so that when a translation is needed, the translation memory is searched for equivalency. Translation memory is not a new concept. Lots of companies that need to produce multilingual documents make use of Computer Aided Translation (CAT) memory tools, such as Lion Bridge, We Localize, SDL Trados, WordFast and De'Jarvu, to increase the speed of the translation. However, these systems are generic and translation organisations do not make their translation memory available to client users. In the current working practice, most agencies/businesses keep their own copies of translation memory or use manually amended Excel spreadsheets.

PAGL has a contextual Translation Memory System. The difference between PAGL and CAT memory tools is that any PAGL translation stored in the memory has reference to the context in which the translation was done. In other words the translation memory is paragraph specific and geared to the language in a text box going into multiple languages and being managed on a document or artwork basis. Thus a paragraph or phase can be stored with reference to as many languages as the translation requires together with the context (brand, type of document, company, etc). CAT memory tools simply store language pairs, providing the equivalent word or phrase in another language, in other words a one-to-one relationship between words and phrases compared to a one-to-many relationship in PAGL. Quite simply, the use of context improves the quality of the translation undertaken.

PAGL uses a Standard Query Language (SQL) database that stores all the translation memory in a structure linked to the master document by categories and brands or companies. This makes reuse of the memory a simple click. For instance, glossary items and commonly used phrases have their own categories with higher priorities simply because they are potentially the preferred translations at any stage of the translation of a document, while user entries and translation memory stored via artwork/document upload or data import are kept under separate categories respectively with different references. Translators or proof readers can chose to work live in the system or in the traditional way with text editing in Word. In the live environment, they are automatically prompted with the matching translation memory for the specific language that they are working on, in which case a pre-translated phrase or paragraph can be entered in a flash. With text editing in Word, the system is capable of providing an exported RTF document filled out with the available translation memory depending on the priorities as discussed above. The translator or proof reader after working on the document, can then upload the Word document and PAGL builds a new version of the artwork or document by language. Last but not least, any translation undertaken is added to the translation memory, which means that the translation memory will grow over time and the volume of translation that can be achieved through the translation memory will increase. Taking the long term benefits into account, the cost saving for page building is undeniable and irresistible.

5 Key Technical Features

The most exciting technical feature of PAGL is the class based service engines, function related processors and configurable service packages based on customer needs, which oversee all the system activities from uploading a master artwork to signing off a finished piece. All the user interactions with system are handled by different class engines or processes according to the assigned service packages. From the business point of view, it is therefore very easy to control the service level of each client through costing plans and possible service upgrading.

Furthermore, the Access Control Level (ACL) component specifies each user's authorised access points within the system, making all users to contribute their part and work more effectively within a multi-login system in a more mannered way. Managers now have a complete picture of what each user is supposed to do in the system. Task delegation and access security has been made easier and more straightforward as the built-in ACL control panel displays a clear overview of each user's privileges in details. To grant or deny a specific access point to a particular user is feasible although default settings have been pre-determined by the system automatically.

Automatic task tendering by language, specialisation and rates helps managers delegate translation tasks in a more reasonable way. Tendering a piece of work is easier with the built-in language filter, specialisation mapper and rates ranking. All communication is conducted through automated system emails or, if preferred, the online private message system. A separate profile site named Trans-Creation Portal (TCP) has also been launched as part of the PAGL project (available at www.transcreationportal.com) to support PAGL with a translation community by feeding through highly rated and recommended copywriters, translators and proof readers. TCP is an online communication platform for all the trans-creation users, managers, and purchasers, or simply put, a Facebook for the ever-growing trans-creation industry. TCP enables its members to create profiles, groups and networks to raise more business opportunities for their own benefits. This acts as a value feed to PAGL in the search for translators and proof readers.

Challenging the traditional blind translation, PAGL is offering a revolutionary real-time visualised translation platform within the client's preferred browser. With the live preview offered by the selected service engines, translators and proofreaders are working in a vivid trans-creation production environment that always keeps them on board with the assistance of a progress bar and instant word count, which to certain extent evokes the feeling of involvement and achievement.

The built-in machine translation tool makes the pre-workflow preview possible, suggests a quick translation and, most of all, gives the task manager, who might not necessarily know the other languages, a feasible solution to task management. A basic costing solution including currency exchange is also included as a handy tool for task managers.

Version control records every artwork version update and makes the change of artwork design no more a nightmare to studio workers as all the artwork versions are updateable and restorable regardless of the "text-within-the-artwork".

Last but not least, the multi-language user interface by user login truly reflects the fact that StorePOINT is an innovative artwork automation company that speaks languages.

6 Future Work

PAGL is going to be an ongoing project that aims to extend support to generic InDesign, Word, PowerPoint, and other commonly used file formats that have been used in the trans-creation industry. With a mind to open source, a self-service site will be set up to allow users access to the PAGL basics free of charge with just machine translation available, which potentially markets and sells PAGL itself while powering this promising industry. The translation memory interface will also be set up as a public site that allows any user to make use of and consequently contribute to PAGL. Currently a working prototype has been released but is limited to system administrators. As a language company, StorePOINT will have its own translation site that is similar to Google Translate but with all the ever-growing PAGL translation memory, which eventually supports the live chat-room and instant online messenger system that could be bolted onto PAGL.

In addition, the Trans-Creation Portal needs more work done to become a professional translator's community that will allow a powerful search for available global language resources. The next stage will involve a better rates look-up system, optimised member ranking, and a self-service model for user interaction and communication.

7 Conclusion

PAGL can be used to assist in the translation process of any document where the layout and design is fixed but the document needs to go into different languages. The system has immediately reduced the cost of the process of adapting documents and artwork into other languages. Translation is charged for on a word count basis and the use of translation memory reduces the word count of a translation and therefore the cost of translation. This also reduces the time taken to do the translation and, combined with the automation of the entire workflow process, the overall production time is significantly reduced enabling StorePOINT to outpace its competitors in artwork production time. In addition, the quality of the finished article is enhanced through the production control process embedded in the system and with the availability of the artwork online at all stages of production enabling all involved users to see the effects of any changes. Quality is also enhanced through the version control that enables a return to a previous version of the artwork if required and, last but not least, by the use of contextual translation memory. PAGL presents a fully meshed and collaborative workflow where administrator, translator, proof reader and approver all see what has been entered in a real time page building web environment.

POINTandGo! Localise is ideally suited to the production of any document that originates in QuarkXPress or InDesign, for example, product brochures, packaging, catalogues, government leaflets, directories, etc. The combination of vision and ideas from StorePOINT combined with the skills of the KTP associate and Kingston University has enabled the building of an innovative system that has the potential to revolutionise the way in which artwork is produced in the future.

A Multidisciplinary Knowledge Transfer Partnership in Development of Lift Simulator

Adrian Godwin[1], A. Ordys[2], Jaroslaw Francik[2], Andrew Curley[2], Piotr Smolenski[1], and Richard Burley [1]

[1] Lerch Bates Ltd.,Woking, Surrey, UK
e-mail: adrian.godwin@eu.lerchbates.com
[2] Kingston University, London, UK
e-mail: a.ordys@kingston.ac.uk

Abstract. Lerch Bates Limited are consulting engineers specialising in short range transportation systems for moving people and materials. Projects include the Taipei 101 Financial Centre and the new Burj Dubai Tower, which is the world's tallest tower, completed in 2008. As the building are becoming more and more complicated, so are the transportation systems in them. Lerch Bates decided to join forces with Kingston University to develop a computer simulation system for lift design. This system is strategic to the company, not only in terms of its reputation as the world-leading consultant in people transport systems, but also in terms of cost efficiencies realisable both to internal staff and the architect / developer of a given project.

This paper addresses the work done within the Knowledge Transfer Partnership for designing building passenger vertical transportation systems. This was a multidisciplinary project, requiring knowledge transfer in the areas of dynamics, control systems, development of dynamic simulation systems and computer graphics/visualization. The design and specification of lift systems for large buildings is a very complicated process, with a wide range of variables that need to be evaluated in order to design a system that will deliver acceptable performance. Such evaluation is performed with the help of computer simulation software. The limited functionality of the currently existing programs for lift simulation however prompted the project to pursue the development of a new system, suitable for the demands posed by modern building designs and improved control algorithms. The project provided the calculation and simulation modules together with the generation of the visual simulation and building information model.

Keywords: dynamic simulation, control of elevators, software systems, visualisation software.

1 Introduction

Lerch Bates (LB) Limited are consulting engineers specialising in short range transportation systems for moving people and materials. These services include

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 115–123.
springerlink.com

vertical and horizontal transportation (e.g. lifts, shuttles and escalators), façade access, facilities management, non-clinical support services, materials handling and management and disabled access. The majority of the company's projects involve consultancy for installations in new or refurbished buildings provide, with maintenance supervision (facilities management) accounting for the rest of their work. LB's customers include property owners, developers, and architects; projects include the Taipei 101 Financial Centre and the new Burj Dubai Tower, located in Dubai, which is the world's tallest tower, completed in 2008.

Due to the success of their first Teaching Company Scheme programme which focused on Facilities Management, the company wished to further exploit their developed relationship with Kingston University as key R&D support for this strategic development need. The Knowledge Transfer Partnership undertook to develop an expert system for designing building passenger vertical transportation systems. The design and specification of lift systems for large buildings is a very complicated process, with a wide range of variables that need to be evaluated in order to design a system that will deliver acceptable performance. Such evaluation is performed with the help of computer simulation software. The limited functionality of the currently existing programs for lift simulation however prompted the partners to pursue the development of a new system, suitable for the demands posed by modern building designs and improved control algorithms. The partners have completed the calculation and simulation modules together with the generation of the visual simulation and building information model.

The development of such a system is strategic to the company, not only in terms of its reputation as the world-leading consultant in this area, but also in terms of cost efficiencies realisable both to internal staff and the architect / developer of a given project. From this, developers will be able to view key outputs; the space take, performance and capital cost of a solution, allowing them to make commercial decisions about the optimal system to meet their need.

The project involved collaboration between Lerch, Bates and two Faculties from Kingston University, namely Faculty of Engineering and Faculty of Computing, Information Systems and Mathematics. The Faculty of Engineering contributed expertise in the dynamics and in control design whereas Faculty of Computing, Information Systems and Mathematics contributed expertise in the software implementation, 3D visualisation, and software integration. The project employed two Research Associates: one in the area of dynamic simulation and control of lifts and one to cover the software development aspect. The project has been completed successfully with a "beta version" of the system operational and ready for use.

2 Background to the Project

The design and specification of lift systems for large buildings is a complex process. This complexity is demonstrated by the fact that many systems already adopted in high rise buildings are considered sub-optimal. Large modern buildings often incorporate shuttle lifts that take people to a sky lobby, from which local lifts take people on to their final destination and, to date, it has not been possible to model this whole system.

In the late 1970's the use of computer simulation to evaluate lifts systems was introduced by Barney and Dos Santos (Barney and Dos Santos, 1977). Around 1998 a PC-based simulation program was developed for general use by Peters (Peters, 1998).

This program, called ELEVATE, enabled users to model most types of buildings with associated lift control systems and types of traffic. It could not look at multiple groups of lifts in operation in parallel nor did it account for designs involving sky lobbies, double deck lifts with new so-called "destination" hall call control or address the various other important parameters of design including building space taken, capital cost estimates or the generation of a 3-D Building Information Model of the proposed lift services.

Currently the "state of the art" from the viewpoint of independent lift system simulation resources is the availability of either "PC-LSD", a program developed by Barney or "Elevate" a program developed by Peters.

The limited functionality of the current programs means that the designer must have considerable experience and tacit knowledge of how to address all the variables involved. The current systems are also not compatible with the planning requirements of modern lifts which now increasingly incorporate destination hall-call control systems where users "book" their calls even before they enter the lift lobby.

Recent advances in software development have provided the opportunity to develop an Expert System based upon a Building Traffic Simulator. Such a system would allow consultant's expertise in the form of rules that could be captured together with their in-depth knowledge of lift system design, to meet a wide range of needs.

Moreover, around year 2000 it became feasible to start and portray lift systems visually to give clients and architects a more direct understanding of the likely performance of the lift services. Telling the developer that 11% 5-minute handling capacity would represent "poor" lift service was nothing compared to seeing people queuing outside the building to get into it! Such visual simulations were "job specific" and very expensive, often costing over £20,000. In 2007 Lerch Bates approached Kingston University with an ambitious project. In summary we wanted an all-in-one system to deliver calculation, simulation, 3-D visualisation and an architectural building information model all to be delivered as output files, including:

- Calculation engine to perform basic calculations of lift design parameters, such as speed, capacity, average waiting time, depending on the traffic patterns in the building.
- Dynamic simulation of the operation of lift systems, with passengers generated randomly over a given time period.
- Advanced control algorithms incorporated as "plug and play", so that new algorithms could be potentially added to the simulation.
- 3D calculation of the space taken, i.e. physical dimensions of a system that can be transferred as a Building Information Model into architectural CAD packages. This enables the building efficiency to be calculated i.e. the net to gross rentable space figure.
- Graphical performance output demonstrating the system's performance under differing traffic situations, efficiency curves and information in graphical format.

- Visual demonstration of performance to interested parties e.g. architects and developers enabling any long wait passengers or substantial queuing to be seen in a visual simulation of the operation of the lift services.

3 Simulation Structure

Computer simulation is especially valuable for large buildings when the traffic patterns are more complicated. Primarily simulation allows the relative capacity of different elevator configurations to be analysed, especially for peak traffic, in terms of "quality" and "quantity" of lift service.

The traffic simulation solution developed uses the concept of a so-called 'simulation platform' which performs all the underlying functions and processes of car movements and passenger activities. As seen in Fig. 1, the simulation platform consists of four parts; passenger generation, car jump model, individual car controller and the group controller. The group controller implements the passenger allocation to individual lift cars and is responsible for overall performance optimization. It will be described in more detail in the next section. The three main elements in the simulation platform are passenger simulation, car jump and individual car controller.

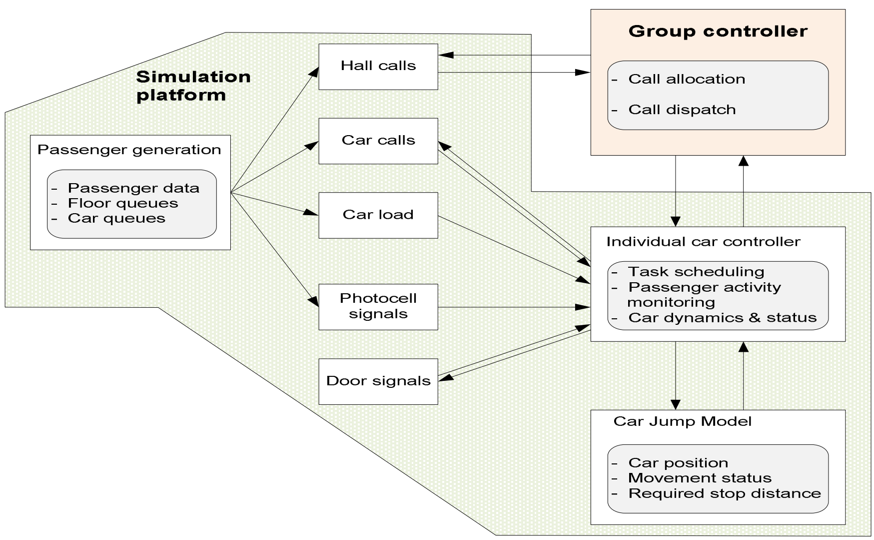


Fig. 1 Elevator traffic processes (adapted from Siikonen 1997)

Passenger generation is the starting point for traffic simulation. The arrival and destination floors of individual passengers are random but they statistically follow a given or measured population distribution in the building. The Poisson arrival process takes account of passenger arrival time. Passengers are externally generated and are introduced to the model one by one at their arrival time. Every passenger is listed in the queue information and given a unique identity number.

The car jump model describes the movement of the elevator car within the shaft. There are basically three jump scenarios in typical floor to floor car movements:

1. The lift reaches full speed and full acceleration. This is typical for a low speed lift moving from floor to floor or a high speed lift making a multiple floor run.
2. The lift reaches full acceleration, but not full speed. It is typical for a short distance run for a high speed lift, where the distance travelled is not enough to accelerate up to and decelerate down from full speed.
3. The lift does not reach full speed or acceleration. This scenario corresponds to very short trips, e.g. single floor.

The **individual car controller** coordinates the operations of each individual car such as loading and unloading passengers selectively upon the car stopping and control of next destination stop for car movement. It takes account of functions inside the car, e.g., registering and cancelling of car calls, opening and closing of the door, passengers loading and unloading and measurement of the car load. It has two major functions, one for jump task scheduling, which means taking the hall call allocated from the group controller and car calls registered by in-car passengers to issue a destination signal for the car jump model; the other is monitoring passenger activity, which includes selective passenger loading and unloading upon car stops, appropriate passenger identifying methods compatible with passenger tracking and logging their every movement in the activity log.

The **Group Controller** algorithm represents the software installed in the group controller, which decides when, how and what to communicate to the car controller. The group controller selects one of the algorithms to be used to allocate passenger (hall) calls to an appropriate lift (car) which can service that call.

For each lift in the group, the Algorithm uses the current state of the lift and all its registered calls to create a journey plan for the lift as it follows a Simplex Collective algorithm (*answering all its registered calls at floors encountered in its current committed direction of travel to one end of the shaft, then reversing and answering all its registered calls in the opposite direction, then finally answering all its registered calls for its current committed direction of travel that are at floors currently behind the lift*). The journey plans include relative timings of arrival at each planned floor stop, which represent the estimated time to cancel the registered calls at the floor for the current committed direction of travel.

Two types of hall call are considered: **Conventional** (Directional) calls and **Destination** calls.

Calls are *Conventional* when only the Origin Floor and the requested Direction of Travel is known. In general, only one conventional call can be registered per floor per direction at any one time.

Calls are *Destination* calls when both the Origin and the Destination Floors are known and the requested Direction of Travel may be computed by comparing them.

4 Software Development Structure

The application is developed as four distinct sub-systems (Fig. 2): *Calculation*, *Simulation*, *Visualisation* and *Reports*, which can be selected independently and which are linked together via a user front end. Extensive use of XML as a means of passing information around the application allows the system to be customised for the applications usage and for fast transfer of data. No database is utilised removing the accompanying drag on resources that is needed to run a database engine. The coding language C#(C Sharp) is used for the majority of the application, which allows the importing of other DLL's written in languages such as C++ and COM to be accessed via C# code. This helps future proof the application as add-ons can be written in the developer's language of choice.

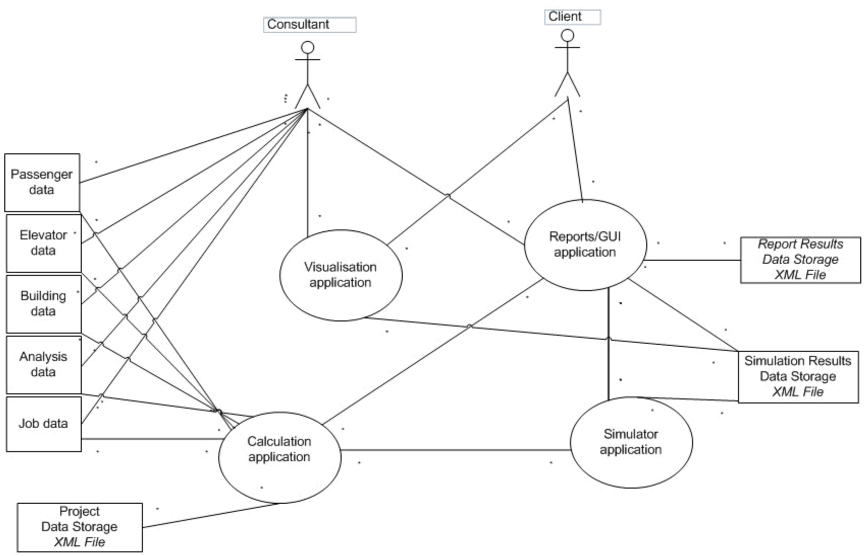


Fig. 2 Software structure

5 3D Drawing Information and Visualisation

There is a growing movement in the architectural world to produce drawings in 3D. Our application constructs a Building Information Model (BIM) for the essential 3D structure of the lift shafts and lobbies and exports it applying IFC – the Industry Foundation Class (IFC Wiki, 2009), a file format that is now a well established standard in industry. This model is built using either data directly involved in the simulation process or automatically derived from the specification of the lift system chosen by the user, with most parameters exposed for further manual tuning. Once the final structure of the lifts, shafts and lobbies is decided, the information model may be easily and effortlessly fed forward to the architects using CAD tools.

The 3D structural model of the building is also used internally, by the 3D Visualisation Subsystem. This module, based on a FreeWill 3D animation framework developed at Kingston University for several years (Szarowicz et al 2005) provides a facility to observe the movements of passengers and elevator cars in the building. It may strongly influence the decision making process as it provides highly visual content to illustrate the performance of the lift services. For example, by introducing colour coding of the intending passengers based upon their expected waiting times, an instant visual cue is provided that allows the user to easily spot queues of lift users with excessive waiting times.

The visualisation module renders the building structure and populates it with 3D animated human characters (Fig. 3). They are driven by the simulation subsystem outcome. To achieve the proper ‘look and feel’ a normal human-like behaviour must be reconstructed, or simulated, automatically by the system. The population of passengers is therefore modelled as a swarm of autonomous distributed agents. The goal of each individual is to fulfil their “script” but, in the same time, to behave like a human, and first of all to avoid collisions with other passengers as well as architectural elements. To achieve this, a novel algorithm for time and space constrained crowd simulation has been developed.

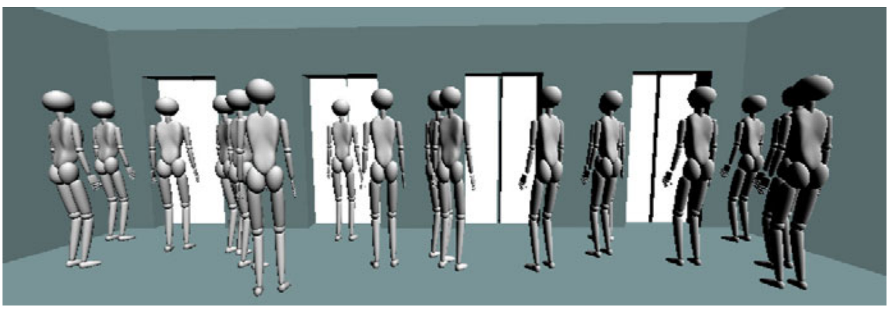


Fig. 3 Lift lobby rendering

6 Conclusions

The novel design tool developed in this project has opened many interesting research avenues and will benefit the project stakeholders in the future. At Kingston University the project has contributed to the development of teaching case study materials and used at undergraduate and postgraduate level. Furthermore, the partners have co-authored an academic paper that was submitted, accepted and presented at the *International Conference on Systems Engineering* in Coventry in September 2009. The company now has the capability to express the expertise it can bring to projects in an instantly impressive and conclusive manner which is accessible & understandable by all who view it, regardless of their seniority and / or technical expertise. Additionally, it provides a stream-lined and polished reporting tool, again boosting the quality of client-facing documentation. Finally, it has created a platform which is both powerful & flexible enough to continue delivering these competitive advantages to the company partner.

The current knowledge transfer relationship Lerch Bates and Kingston University is excellent and this association is advertised widely through case studies, publications, posters and video interviews. Further undergraduate and postgraduate projects to improve the system capabilities are in place. The Company will also provide new employment opportunities for Kingston University graduates in the future in the fields of system simulation and computer science.

The Knowledge Transfer Partnership contributed to this relationship by bringing together the academic and industrial partners to develop the novel products and services now supplied by the Company. Every member of the project team gained tremendously from the experience.

The knowledge transfer process between the partners has developed a new design tool which will enable a more informed selection of lift design to be made by comparing the relative traffic performance, space-take and capital cost of each solution It will also be possible to quickly analyse the effect of changing input variables e.g. occupational densities upon the performance of the lift system.

The project benefited the Company, the Knowledge Partner and the Research Associates involved.

For Lerch Bates, the main benefits are in:

Market position and reputation. Ever more ambitious construction projects that utilise ongoing advances in civil engineering will require an understanding of the entire people moving system. There is also a growing need to design more flexible buildings that can adapt to a variety of uses, a requirement that can only be met by accurate modelling. The efficiency and predictive nature of the developed system will enhance LBs position and reputation as lift consultants, making them the preferred supplier of consultancy services in this area.

Improved efficiency / profitability. The system will enable engineers to efficiently design, specify and model options. The developed system will be able to apply company knowledge to bespoke building specifications, saving consultant engineers time and thus improving efficiency.

Increased turnover / growth. The system will increase the efficiency of the existing LB workforce and consequently the volume of contracts that LB can undertake. This, combined with synergy with industry standard architect systems, and the facility to visually present preferred options to developers, will secure a major competitive advantage that will improve LBs tender success rate as the preferred supplier.

For the University, the main benefits are:

All academics involved in this project benefited by gaining or improving practical knowledge and experience in the following topics:

- Operation of elevator systems, machinery used, electronics, modes of operation, elevator industry standards,
- Modelling and simulation of elevator systems,

- Optimisation and control algorithms for elevators, real life constraints and current approaches in industry,
- Crowd simulation in time and space constrained environments.

During the progress of this KTP project it became apparent that the technologies to be employed were among those considered “hot research topics” in the fields of advanced control design and in the field of visualisation and animation software. This forced the academic supervisors to get deeper into those subject areas and it will benefit future research at Kingston University. It is hoped that the research on this subject will be continued, benefiting from experience gained in this project.

The research in 3D visualisation, animation and, more recently, computer games, have been carried out in Digital Image Research Centre at Kingston University for almost 10 years now. The visualisation module delivered within this Knowledge Transfer project is based on Free Will, an animation framework developed in 2003-2005 as a part of a EU-funded research project. Realistic crowd simulation was a vital part of that project and a new algorithm for time and space constrained human character control is a valuable contribution to this research. New experience in animation of the human behaviour within architectural interiors contributed also to enrichment of the curriculum of the newly opened Games Development course, taught at the Faculty of Computing, Information Systems and Mathematics.

For the associates the main benefits are:
A Professional Development Plan is put in place for each associate, highlighting strengths weaknesses and areas for improvement through training. Each associate is encouraged to complete a degree during their associateship and it is one of the main reasons that people become KTP associates. The degrees are based on the work being done and are supervised by the university – Work Based Learning. Time is allowed during the KTP for professional development (10%). A budget is allocated to each associate for extra training. The Associates are encouraged to attend professional/scientific conferences, if relevant, industrial visits are also pursued. In the particular project, all the above activities took place and they were generally, positively received by the Associates.

References

Barney, G.C.: Elevator traffic handbook: theory and practice. Spon Press, London (2003)

CIBSE Guide D, Transportation systems in buildings. CIBSE (2005)

IfcWiki, Industry Foundation Classes wiki website (2009), `http://www.ifcwiki.org` (accessed July 10, 2009)

Reynolds, C.: Flocks, herds and schools: a distributed behavioural model. In: SIGGRAPH 1987, pp. 25–34 (1987)

Siikonen, M.L.: Planning and control models for elevators in high-rise buildings. Ph.D dissertation (1997) (2007)

Szarowicz, A., Francik, J., Mittmann, M., Remagnino, P.: Layering and heterogeneity as design principles for animated embedded agents. International Journal of Information Sciences 171(4), 355–376 (2005)

Using Information Systems to Drive Process Change: An Aerospace Industry Example from the Knowledge Transfer Partnership Scheme

Martin Wynn and Raul Brandao

University of Gloucestershire Business School
e-mail: {mwynn,rbrandao}@glos.ac.uk

Abstract. This paper explores the growing role of shop floor systems in overall information systems strategy and how the Knowledge Transfer Partnership scheme was used to implement an integrated suite of shop floor systems in a major aerospace company. It also focuses on the significant process change that accompanied the introduction of new systems and the benefits this has brought to a company that has to meet large scale orders for aero engine components sometimes placed several years in advance. The paper also illustrates how shop floor engineering systems can be integrated with mainstream corporate systems.

Keywords: Shop floor systems, IS strategy, knowledge transfer, systems integration, product lifecycle management, process change.

1 Introduction: Information Systems and Process Change

Probably the most debated area in which the introduction of new systems is associated with process change is in the context of Enterprise Resource Planning (ERP) systems implementation. These large scale software packages normally encompass the main transaction processing and information reporting requirements of a company, spanning sales order processing, financial management, human resource management, stock movement and inventory control. Benson et al's (1992) 'staple yourself to an order' example in the early 1990s illustrated well the potential for process improvement and introduced many practitioners to the concept of function vs. process. This was developed further in the 1990s by Michael Hammer (Hammer and Champy, 1993) who argued that process change was essential to business survival and acknowledged that this could be associated with new information systems (IS). Hammer argued that there was no scientific definition of processes, but that in his opinion there were three main business processes that could fit most company operations: 'obtain an order', 'fulfill the order' and 'new product development'.

In the engineering field, the introduction of new systems and process thinking paralleled the development of the concept of full product life-cycle management for

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 125–134.
springerlink.com

engineered products, from concept through design and engineering, to manufacturing, delivery and even product performance on client sites, spanning the new product development and order fulfilment processes identified by Hammer. This gave rise to Product Lifecycle Management (PLM) systems, which can be defined as a general plan of the product lifecycle in a particular business or product area. It is a compilation of business rules, methods, processes and guidelines as well as instructions on how to apply the rules in practice (Saaksvuori and Immonen, 2002).

The engineering industry already used a range of specialist (largely standalone) systems including computer aided design (CAD), computer aided manufacturing (CAM), and computer aided engineering (CAE) packages, but integration with company wide ERP, manufacturing requirements planning (MRP) and data warehouse systems was not commonplace. This paper examines how the introduction of new integrated shop floor systems in a major aerospace company has been a driver for significant process change.

2 Shop Floor Engineering Systems

For many years, systems in this field were limited to programmable logical controllers (PLCs) and associated supervisory control and data acquisition (SCADA) packages and computer aided design (CAD) tools. Product lifecycle management (PLM) systems evolved from earlier product data management (PDM) systems (Stark, 2005). PDM systems can be seen as a subset of a PLM system. In the 1980s, engineers had recognized the need to manage the increasing volumes of design data produced by, and contained in, a range of automated and semi automated systems, such as CAD files, specification and requirement documents, and CAM and CAE analytics. PDM allowed the user to store and control all product data, manage document issue levels, maintain bill of materials and immediately visualize the relationship between parts and assemblies.

However, being able to manage the data alone was not enough. There was the clear need to manage the entire product lifecycle, of which product development is just a part. According to Ameri and Dutta (2005), a product lifecycle can be divided into 5 stages: imagine, define, realize, use/support and retire. The first three stages are part of product development but engineers needed a more comprehensive system to support both product development and the full product lifecycle. PLM is a compilation of business rules, methods, processes and guidelines as well as instructions on how to apply the rules in practice (Saaksvuori and Immonen, 2002). The PLM concept encompasses several systems. Ameri and Dutta (2005) describe change management, document management, workflow management and project management as PLM systems that support concurrent engineering and streamlined product development processes. PLM seeks to extend the reach of PDM beyond design and manufacturing into other areas like marketing, sales and after sales service.

PLM extends PDM functionalities to include the creation of product definition information as well as the management and control of such information. PDM is focused on the management of data created by information authoring tools, whereas PLM also includes the authoring tools themselves. PLM seeks to fill the gap between enterprise business processes and product development processes.

3 Company Profile and Project Background

ASP UK Ltd has a turnover of circa £17m and employs 250 staff in the southwest region of the UK. It is part of the ASP group, which is considered the largest bearing manufacturer worldwide. ASP UK currently holds approximately 7% of the world market in aero engine bearings, the majority of which derives from major aircraft engine manufacturers. To retain existing market share and create opportunities for new business, the company needed to be more efficient in providing engineering data and more cost effective in its operations to be price competitive. A key tenet of this strategy was to effect a major upgrade of their shop floor engineering and associated technology infrastructure to allow them to compete more effectively.

The knowledge transfer partnership (KTP) project was central to the implementation of the systems upgrade strategy. ASP UK was the first ASP group company to implement this strategy, and thus the final product selection and its implementation on the shop floor to be important precedents for other group companies. The lessons learnt from this implementation are transferable as other companies in the group attempt similar shop floor process and infrastructure improvements. In addition, the KTP project made a major contribution to the cost competitiveness of the business by providing more efficient and effective engineering and data management capabilities.

4 Overview of the KTP Project

"To plan, develop and implement an integrated engineering information system to support future business competitiveness based on improved customer responsiveness" was the project mission statement for the KTP project. The implementation of a new PLM system as well as new CAD/CAM packages, both linked with ERP and shop floor data systems, was seen as essential to support the company in delivering big contracts to its main customers. The main software products were NX (CAD/CAM) and Teamcenter (PLM). Within the company, the KTP programme was named the "Engineering Systems Integration" (ESI) project (Figure 1).

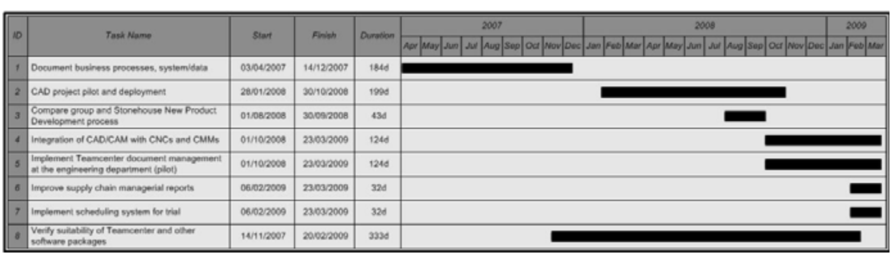


Fig. 1 Project timetable for ASP ESI project

The objectives of the ESI project were to:

- Create a business process map which encompasses the company's main business processes (Figure 2)
- Implement NX (CAD/CAM) and manage the NX project pilot
- Manage the basic Teamcenter (PLM) implementation
- Evaluate and cost justify the need for, and benefits of, other software packages
- Define and implement the integration of NX and Teamcenter with coordinate-measuring machines (CMMs) and computed numerically controlled machine tools (CNCs)
- Implement managerial reports using business intelligence tools (Cognos Pro-IV)
- Implement a shop floor planning system

Fig. 2 Main Business Processes at ASP UK Ltd

The project was divided into distinct stages (Figure 1) and project managed using selected elements of the PRINCE2 methodology (Wynn, Shen and Brandao, 2008). The initial stage focussed on industry knowledge gathering, and process mapping. The KTP Associate (employed by the local university, but working full-time at ASP) held a series of workshops with management and shop floor staff to get agreement to the process maps and start to identify areas for process improvement. This established the Associate's credibility and role brief with the company's engineers and paved the way for stage 2 which saw the implementation of the CAD system on the shop floor, moving users to a three-dimensional CAD environment. This reinforced project momentum and broadened support for the KTP programme as a whole. As part of stage 3, the process maps (Figure 2) were revisited, and the project team spent some time examining the overall group processes for product development and production, and the implications of group software strategy (which favoured the NX/Teamcentre PLM software combination).

Stage 4 refocused on software implementation and developed links between the CAD/CAM functions and the shop floor machines (CNCs and CMMs) where the major focus is on product quality and precision after each operation of the product's development. The initial raw material goes through a sequence of operations that involves CNCs and/or manual machines shaping the component and CMMs verifying whether those machines achieved the tolerance required by each stage on the product line. To have a machine program downloaded to the CNC, a Direct Numerical Control (DNC) system can be used which provides program version control and the logging of program interruptions and necessary amendments. The implementation of the 3D CAD/CAM system fully integrated with the CNC and CMM machines was the first ASP aerospace business within the corporate group to achieve this (Brandao and Wynn, 2008).

Stage 5 delivered the implementation of the Teamcenter document management system in the engineering department, delivering significant time saving benefits for information retrieval. Until then, the company was still using print copies as their master copy for auditing and even for product changes. By making the digital copy secured and all the product information also being held in the PLM system, the management and maintenance of product development and change control became faster and more secure.

Stage 6 reflected a change of focus as business priorities and staff personnel changed. The Associate was now tasked with assessing possible information improvement across the broader supply chain, and his main achievement was the development of new management information, using the Cognos business intelligence tool running on the CHESS MRP system (Figure 3).

Software packages implemented at ASP were CHESS (MRP), Teamcentre (PLM), NX (CAD/CAM) Seiki (advanced scheduling) and Cognos Pro-IV (business intelligence/reporting).

The concept of customer facing product channels was introduced to drive new efficiencies on the shop floor. This divides the product portfolio into categories, and machines are aligned in sequence on the shop floor creating product category lines. Before the introduction of this concept, the shop floor was laid out with the same type of machines being clustered together in cells. A separate project was set up to implement this process change, but key information was needed to make the most of the concept. To establish what could be the 'bottleneck machines' in each channel before the channel was fully implemented was a key challenge, so that appropriate redesign of the channel machine configurations could be made. Various reports were required on a daily basis by the channel implementation team, and these were developed using the selected business intelligence tool (Cognos Pro-IV).

In addition, the supply chain function was further developed in Stage 7, where the Associate undertook package evaluation for other supply chain systems, notably scheduling, leading to the selection and pilot implementation of a new scheduling software package (Seiki). Prior to this, lead-time calculations were difficult to estimate due to the number of orders, the quantity of operations for product development and the limitations of the corporate MRP package in visualizing the impact of any changes on the shop floor. In addition, due to a long lead-time for aerospace product development, some customers forecast orders for the next 3 years and, to be able to secure these, the company had to prove it had available capacity over that period. The scheduling system implemented provides the ability to simulate those conditions and report an accurate picture of future capacity. This completed a major overhaul of the company's IS portfolio (Figure 3).

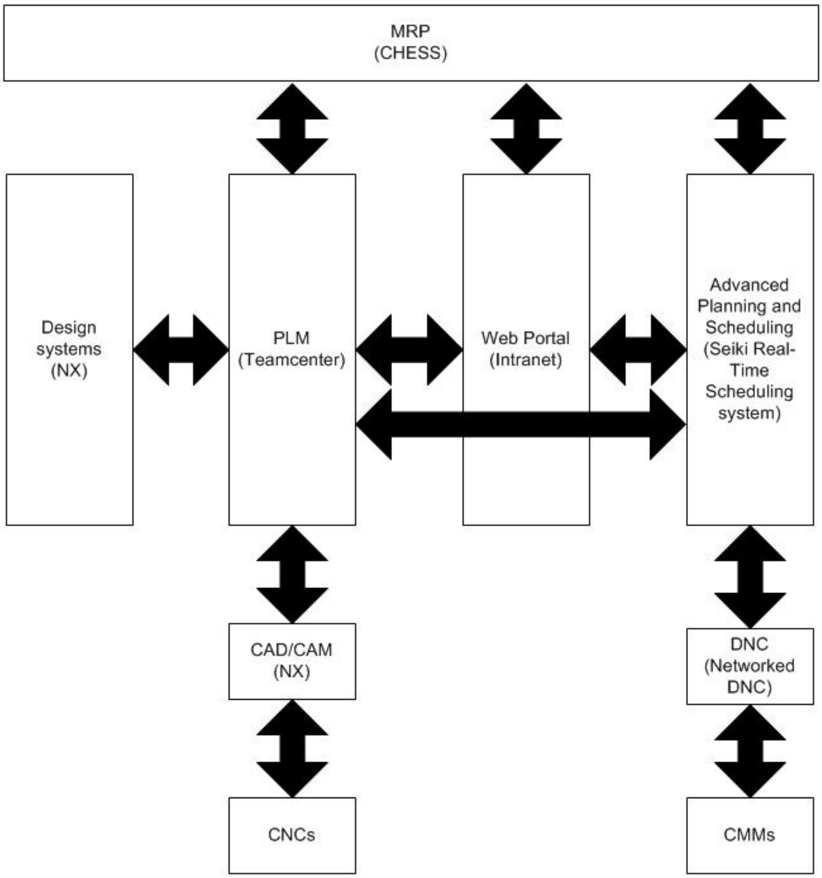


Fig. 3 Selected Software Solutions and Systems Architecture at ASP UK Ltd

5 The Implementation Process

At the first meeting of the Project Board, it was recognised that for the project to be successful, there would need to be three parallel running and inter-related streams of work – process, technology and people/training streams. A senior manager was allocated to each of these three streams to act as overall owner and coordinator of activities.

The implementation of the new technologies started with an overview of the business and the core processes involved directly with business revenues. Some Six Sigma techniques (such as spaghetti diagram and lead time analysis) were applied in order to understand where priority focus was required. Other sites (and even competitors) were visited and analyzed, to ascertain what technologies were used to address each of the company's key process areas. After a careful analysis, the implementation of 3D CAD/CAM and PLM systems was embarked upon.

The second priority was to improve key operational (and strategic) decision-making by providing accurate information to senior managers and the managing director. It became clear that a new approach was needed to provide quality management information from an evolving technical and systems environment and a business intelligence (end-user reporting) tool was installed (with appropriate training) to extract information from a number of key systems. While the development of the reports required complex tasks to be done, the usage of them is relatively easy and required minimal training or process adjustment.

Third, the issue of managing shop floor load and future production capacity needed to be addressed and the Seiki real time scheduling software package was chosen after a review of available package options. The implementation required integration with other systems but the major problem would come later with driving through the associated business change. By implementing these new technologies, it was clear that processes needed to change and improve to deliver the benefits of the new systems. It was accepted that process improvement initiatives often require change in staff attitudes, knowledge, practices and procedures, which in turn requires training and embedding of new concepts and awareness.

The change from 2D to 3D design and engineering brought major process change in this area. Initially, the development of a new product was taking longer due to the nature of the 3D system, but the increased accuracy of the design and machine programs generated by the new system made this cost effective overall. In addition, the change design process was much quicker due to the new product development process, which integrated each operation with the product design.

Significant training was necessary on a number of implementation fronts: design/development, programming, post-processing and new product development, and change management. From the outset, significant effort was dedicated to helping engineers to come to terms with, and embrace, the new processes and systems, which in the end produced the institutionalization and embedding of new ways of working.

In this aerospace business, there were some difficulties in implementing some of the new technologies, for example the CAD/CAM. Theses systems work very accurately in automotive businesses and are well matched to their business requirements. However, some difficult design shapes are needed in aerospace, and knowledge from the company used on the 2D system was effectively converted to the 3D CAD/CAM. Another example was the PLM system and its data classification solution. The level of detail handled by the classification was limited in comparison with the levels of detail needed by an aerospace business. Therefore, the PLM developers had to encompass that requirement and introduced limited systems customisations to attend to this business need.

6 Concluding Remarks: Operational Benefits for ASP

New knowledge has been generated and acquired in the process mapping, software package evaluation and implementation that can be carried forward and used in subsequent phases of the project. Indeed, the creation and validation of current process maps generated an understanding of the relationship between departments. This was used in a customer audit to demonstrate new development flows. The reorganization of the design manuals in the design portal improved document management and provided a tool for document retrieval. The integration of the CAD/CAM system with the CNCs and CMMs machines was the first site of the aerospace group division to achieve this integration and provided technical knowledge of machine program implementation that can be used elsewhere in the group.

The company had very little in-house IS resource, but now has the capability to move forward with the implementation and further embedding of the new CAD and Teamcentre systems; and the comparative analysis of local business processes with group level business processes has allowed a move towards alignment of processes and software deployment across the group. The PLM solution implemented had document management, 3D visualization, process management and classification functions. Document management was used across the business while the 3D visualization was mainly used in the design and engineering departments as well as on the shop floor.

The implementation of this new systems portfolio helped bring about a reorganization of the shop floor to halve product lead times for bearings from 90 days to 45 days, with a forward target of 30 days. This involved a radical change in shop floor structure from an organization that reflected management functions to one based around product-customer channels, in which 80% of operations required for product development and delivery are contained within each channel. Seven main channels were identified that crossed and utilized elements of the old functions (e.g. heat treatment, grinding, final view-assembly-packaging – Figure 4). This resulted in faster product flow and less work in progress, and eliminated product data on systems not linked to specific orders. This represents a core process improvement, which, allied to the new technologies and upgrade in people skills, will deliver major benefits and cost savings.

Savings achieved by implementing the CAD/CAM and PLM systems are predicted to payback the investment cost within three years and will exceed a £1m net benefit within 10 years. The Cognos (business intelligence) implementation was done on the basis of the 'difficult to quantify' benefits of more accurate management information and associated decision-making. The implementation of the new scheduling and capacity planning system will allow ASP to take new contracts worth £1.5M per year in 2010, 2011 and 2012. The working relationship and availability of information on the company's engineering database between

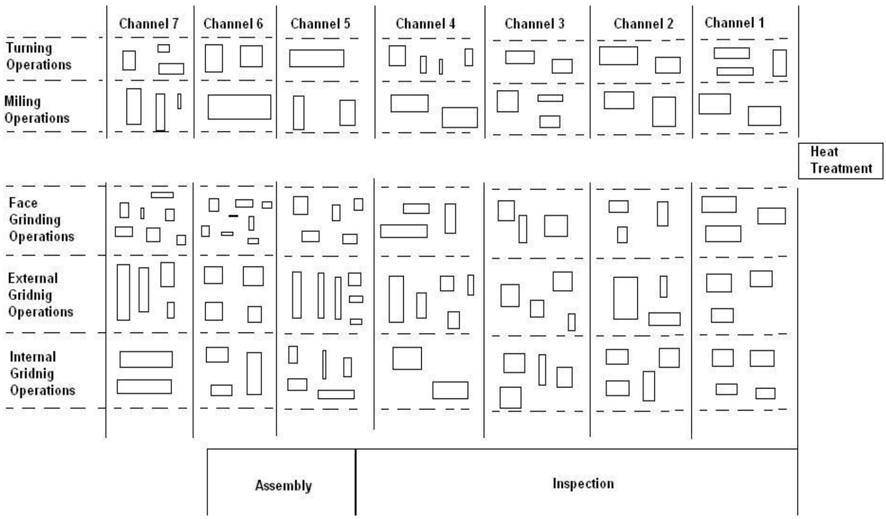


Fig. 4 Shop floor process alignment around channels at ASP UK

departments has been substantially improved as a result of the KTP project. The company's CAD system has been upgraded to meet customer demands and future expectations.

The achievement of the KTP scheme nationwide was recognized by Lord Sainsbury in 2007, when he recommended a doubling of KTPs nationwide and concluded that 'by almost all measures, we have seen a dramatic increase in recent years in the amount of knowledge transfer from British Universities' (Sainsbury, 2007). This article has attempted to illustrate one small part of this change programme, in the development and implementation of a new IS strategy and process alignment in an aerospace company.

Acknowledgements. Acknowledgement and thanks are given to the following in supporting the KTP project featured in this article: The plant director and supply chain manager at the aerospace business featured in this article that will be given the pseudonym ASP UK Ltd because of confidentiality requirements. Acknowledgement and thanks are also given to the UK Government Department of Innovation, Universities and Skills (now Business, Innovation and Skills) for support for this KTP programme. The Partnership received financial support from the Knowledge Transfer Partnerships programme. KTP aims to help businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base. KTP is funded by the Technology Strategy Board along with the other government funding organisations.

References

Ameri, F., Dutta, D.: Product lifecycle management: Closing the knowledge loops. Computer-Aided Design and Applications 2(5), 577–590 (2005)

Benson, P., Shapiro, V., Rangan, K., Sviokla, J.: Staple Yourself to an Order. Harvard Business Review, 113–122 (July-August 1992)

Brandao, R., Wynn, M.: Product Lifecycle Management Systems and Business Process Improvement – A report on Case Study Research. In: ICCGI 2008. IEEE, Los Alamitos (2008)

Hammer, M., Champy, J.: Reengineering the Corporation. HarperCollins, New York (1993)

Saaksvuori, A., Immonen, A.: Product Lifecycle Management. Springer, New York (2002)

Sainsbury, Lord of Turville, The Race to the Top – A review of Government's Science and Innovation Policies, HMSO, Crown Copyright, p. 55 (2007)

Stark, J.: Product Lifecycle Management: 21st Century Paradigm for Product Realisation. Springer, London (2005)

Wynn, M., Shen, R., Brandao, R.: Managing IS projects in SMEs – Tailoring the PRINCE2 methodology. In: 9th International Business Research Conference. Imperial College, London (July 2008)

SME Supplier Management: An Exercise in Change Management

Shilar Bryant[1] and Russell Harbison[2]

[1] Serious Brands, Aylesbury, Bucks, UK
[2] Buckinghamshire New University, High Wycombe, Bucks, UK
e-mail: Russell.Harbison@bucks.ac.uk

Abstract. The problems facing a manufacturing SME in the current UK economic climate are many and varied. This paper describes the experience of a Knowledge Transfer Project (KTP) Associate and her academic supervisor working for a customer-centric company in a dynamic manufacturing environment. With issues ranging from quality of the product itself, supplier relationships, a 'no questions asked' returns policy and a sometimes indifferent manufacturing workforce the paper sets out the problems encountered, the solutions offered and then implemented. Beyond the quick win solutions the real value of the project was a change in attitude which has allowed awkward questions to be asked, considered and not swept back under the carpet. Early indications are that the KTP project has been of major benefit to the company on a number of fronts.

1 Introduction

The company as Sunalex has been in existence for over 25 years manufacturing a variety of lighting equipment for domestic and industrial/medical applications. "When it comes to Reading Lights we know what we're talking about. We've been designing and building lights that help people read and work in more comfort for over 20 years. Originally we built lights for businesses such as clothing manufacturers where employees were putting their eyes under considerable strain. We've even built lights used in tough conditions like on board Lifeboats and the Space Shuttle. Over the last 4 years we have adapted, modified and improved on this original lighting technology to create a range of reading lights for people to use in their own home."

The focus of the KTP project has been on the 'domestic' side of the market in the 'manufacture' and distribution of standard and side lamps. The lights are aimed at the high end of the market in terms of the older generation who require a good light for reading.

"Our customers are discerning mature readers who take an active interest in the world."

The company competes using a customer centric approach. This is an approach to doing business in which a company focuses on creating a positive consumer experience at the point of sale and post-sale.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 135–143.
springerlink.com

'A customer-centric approach can add value to a company by differentiating themselves from competitors who do not offer the same experience.' (Business Dictionary 2009).

This is articulated in 'The Deal' offered to customers, which includes a 30 day risk-free trial:

"We are so confident that you will love our lights, that we offer a 30 day risk-free trial on them. This means that if you're not totally happy with your light then we'll refund the full amount, including any delivery charge and come and collect the light at no cost to you."

In practice, 98% of customers decide to keep the light.
A quality product aimed specifically at the older market that offers to reverse the years when it comes to reading experience: with the title "Why you need a Proper Reading Light", the literature explains:

"Unfortunately, as our eyes get older they need more light to be able to see clearly and to read in more comfort. This is an unavoidable consequence of the natural ageing process of the human eye. At Sunalex, for many years we've been designing Reading Lights that enable you to read in a way that you took for granted when you were younger. You'll be amazed at the difference a proper Reading Light can make! Of course our lights can also be used for any hobbies where you're putting a strain on your eyes such as such as needlecraft, stamp collecting or jigsaw puzzles."

'The Deal' eventually equates to the agreement that the customer can buy the light and return it for whatever reason – no questions, no cost (postage paid by the company); and then get a new light or their money back. This is a 5 year guarantee.

2 The Problems

The original aim of the KTP project was to:

- Research and then apply TQM or appropriate techniques toward the elimination of quality issues.
- Research new materials and methods for production, development and testing of new products.
- Develop and implement advanced production procedures and processes to maximize output of globally competitive specialist products.
- Address a company-wide environment policy need.
- Be a proactive member of the company's management team.

As the project has progressed these aims have been modified slightly in the light of events and the current economic climate – but they are fundamentally still being met.

The initial job of the KTP associate was to:

- investigate the quality issues responsible for the returns and
- then reduce a the number of returns by addressing and correcting the quality issues.

After a simple Pareto Analysis of the returns of light units to the company theKTP associate produced a 'hit list' of areas where low-cost high-impact improvements around these issues could be made.

3 Returns

The 'Deal' allows a customer to return lights for whatever reason. A return would involve paying the return to company packing and postage, examination and repair of the unit and subsequent packaging and return to the customer. These 'returns' are logged and examined on a daily basis. The reason for this daily logging and analysis is obviously the cost of these returns – which at the high of a 3.5% return rate was significant.

It was this 'rate of return' which became the initial focus of the KTP project – although other issues such as light and component design, factory management, personnel attitude, factory and company culture all needed to be considered along the way.

All of the returns are categorized as quality issues and might include a blown bulb, customer not being able to operate the dimmer switch, 'doesn't work' etc. The elimination of quality issues has been the major feature of the work carried out within the company.

Many of the returns were concerned with incorrect orders being picked, packed and then sent to customers. The Pareto analysis showed that picking and dispatching could be an area which would produce some 'quick wins'. One of the most obvious problems was simply the factory layout with the areas concerned with assembly, picking of items, packaging and then dispatch being widely separated.
The initial analysis was done using tools based on recent value-mapping ideas (PH Magnier. (2009).

The main aim of value-mapping is to:

"……..depict material and information flows across and throughout all Value adding processes required to produce and ship the product to the customer. Value stream maps document all of the processes used to produce and ship the product, both value adding and non-value adding (waste) processes."

Mapping of the value stream was completed in the packing area and picking tracks were identified and combined. The area was expanded and better lit than before with the addition of laminated 'reminder signs' and indicator boards (which bulb or accessory was to go with which light). The whole packing process was improved by giving accurate picking lists combined with clear instructions of what and how to pack. This meant that staff were able to perform better and consequently the rate of returns (for packing faults) diminished rapidly.

4 Factory Layout

The project has now developed the value stream from a make-to-stock process to a make-to-order sequence which allows transparency of stock levels and a tighter control on cash flow.

Building on this success the Associate ordered new racking and storage for the manufacturing areas and instigated a general clean up and reorganization of the factory areas. These actions fell out of the Kaizen methodology of elimination of waste (muda) and the 5-S framework for good 'housekeeping':

1. Seiri - tidiness
2. Seiton - orderliness
3. Seiso - cleanliness
4. Seiketsu - standardized clean-up
5. Shitsuke – discipline - standardization.

This initiative coupled with the Hawthorne effect led to a marked improvement in returns and a less marked improvement in personnel attitude.

As with any organizational change there is a well known placebo effect – the Hawthorne Effect – from the studies of Elton Mayo at the Western Electric plant in the late 20's and 30's (Roethlisberger and Dickson, 1939). The Hawthorne effect was derived from a series of controlled studies which found that performance improved as the working environment improved. The strange thing about the Hawthorne effect, and less easily explained was that performance also improved as the working environment changed for the worse!

5 'Green' Soldering

One of the problems thrown up in the initial analysis was that of use lead free solder. The company prides itself on being as eco-friendly as possible (although it had not gone for ISO14001) and ensured that it recycled packaging and manufacturing materials where it could. The company had duly followed the legislation regarding lead-free solder and were indeed using a 'recommended' lead-free solder.

Using is perhaps the wrong word, struggling might have been more accurate. The solder did not melt at the previous temperature and when it did it would not flow or adhere to the terminal contacts as the lead solder had done.

As part of the KTP project the Associate asked if the University could look into this. Professor David Jacobson from the Centre for Design and Manufacture was duly dispatched. He immediately diagnosed the problem that the company had been recommended a machine lead-free solder. After sourcing and 'hand soldering' and better flowing solder, changing the soldering iron tips and transformers the problem was solved to the delight of the manufacturing staff.

This improvement gave much to the reputation of the KTP associate. In establishing this credibility it gave rise to a slightly more welcoming attitude to future changes.

6 Personnel Attitude

There were a number of hurdles which needed to be overcome before the real work of the project could begin. Staff were reluctant to engage in any quality control and would sometimes return faulty lights to good stock without testing them properly. There was little or no ‘listening’ culture within the firm and little sense of quality and particularly any sense of responsibility for quality.

The arrival of the KTP associate was seen as a threat. The status-quo was upset and new attitudes seen as ‘more work for the same pay’.

In order to address these issues the associate began a series of team meetings and a charm offensive in an effort to change attitudes. A healthy eating scheme was introduced (eat more fruit) and any ‘environmentally friendly’ or ‘healthy option’ was heavily encouraged. ‘Music therapy’ (or at least a vote on the best station to play during the day) was also introduced by the associate who purchased a radio to for the express purpose of calming the workforce. It seems to have worked.

Unfortunately the charm offensive coincided with the economic downturn and a number of redundancies and an across-the-board pay cut were forced upon the company. Despite this the general attitude and atmosphere within the company has improved markedly.

7 Suppliers

The next highlight on the Pareto list was the issue of supplier relationships. A number of recurrent faults and design issues had been identified and despite numerous calls, faxes, e-mails etc little had been resolved.

> ‘The first thing that purchasing people can focus on is reducing the supplier base. The more suppliers a company has, the more variation in incoming material and services they will experience, leading to a host of potential problems including poorer quality of the final product. Quicker wear of moving parts, and increased times for handling and assembly times. Companies with a large supplier base miss out on the continual improvements in quality cost and cycle times that a close relationship with a supplier can bring’ (Stocker 2006)

It was decided that the Associate, along with the financial controller would attend the annual lighting expo in China – while at the same time visiting the suppliers on ‘home territory’. This was the first real supply chain management which had been carried out by the company and was guided by the standard approach to the discipline which is:

- The oversight and management of materials and services inputs
- The production process in which those materials and services are used, and
- The provision of outputs that are generated through the use of the acquired materials and services, which is analogous to the fulfilment of customer requirements.

The main cause for concern centred around the transformer and the need for additional driver (for the new LED light) and the difficulties with overheating of some of the supplied units. The vendor meeting and subsequent e-mails resulted in improved moulding design to reduce overheating, a number of design tweaks toward an improved product and, perhaps most spectacular of all, a price per part reduction from $10 to $6.20.

The trip to China was very successful and is to be repeated October 2009. The purpose of the trip will be to:

1. attend the China Lighting Expo and
2. to locate and source a (possible) new supplier.

Many of the problems with the manufacture and subsequent operation of the lights stemmed from the basic design. The cause of these faults and then returns was really the age old problem of the 'over-the-wall' attitude toward design and manufacturing.

> 'Because a particular design is eventually made into a product design and manufacturing must be intimately interrelated' (Serope Kalpakjian, 1992).

The components and assembly design of the lamp were 'taken for granted' and 'got on with'. This meant that there were a myriad of problems in areas of:

(a) wiring connections
(b) direction of assembly and
(c) alignment problems.

In an effort to highlight these problems and give a fresh approach to their alleviation it was decided to allow a group of Product Design students from the University to tour the factory and then to carry out a 'design crit'. The students were studying the module 'Design for Manufacture' and provided some valuable insights.

> 'Each part or component of a product must be designed so that it not only meets design requirements and specifications, but also can be manufactured economically and with relative ease. This approach improves productivity and allows a manufacturer to remain competitive……. This approach is now recognized as the area of "Design for Manufacture"' Serope Kalpakjian (1992).

One of the areas in which improvements were made immediately was the area of wiring within the base of the light which involved the use of a difficult to use joining terminal. This was a recognized problem and various solutions had already been proposed – even by the KTP supervisor. The Product design students saw the problem in a different light and proposed their own solution – to do away with the terminal block and simply solder the wires together. An obvious if inelegant solution but with the addition of insulation sleeving it seemed to offer a solution. This method was tried, tested and evaluated on a batch of units and then adopted as the new wiring joining method. This method had eliminated the need for a wiring terminal and increased the speed of operation for assembly of the light. In addition to these quick wins the students presented the senior management team with a critique of the current design and suggestions for future designs. While not all of these suggestions were wholly practical some good ideas were generated and noted for future work.

8 Burn Tests

All lights were previously tested (on/off) before being packed and sent to the customer. Despite this lights were returned as 'not working' due to blown bulbs or blown transformers. It was then decided to conduct burn tests on each light (2 hours) to ensure that at least some of these faults were revealed.

The burn tests immediately showed up a number of faults and it was decided that all lights would be tested prior to final packing.

9 Aesthetic Considerations

A number of returns around 'aesthetics' of the product were due to mis-alignment of the wooden handle with the flexible stem. A relatively expensive light with faults of this nature did not send the message of quality which the company were trying to project. The Associate started a dialogue with the suppliers and this resulted in a change of design – which went some way to alleviating the problem. It is interesting to note that this particular problem was one which the Associate had to champion. The 'fault' did not show up on the returns and it was only with this 'detached' or 'fresh' perspective was the problem even noticed.

10 Successes

A number of 'solutions' to the various problems were proposed, evaluated and then either rejected or implemented. The TQM solutions employed to address the problems of the company were chosen and applied not as part of a general Total Quality management implementation but more as a series of interventions designed to solve particular problems.

The structure, economic position and 'will' within the company did not allow a general TQM solution and so the specific tools and techniques used were used in isolation. Despite this apparent drawback and less than 'textbook' approach the tools and techniques coupled with the drive and ambition of the KTP associate proved that these tools were effective and worthwhile.

For example the major achievements in terms of value mapping were translated into 'layman's' terms as 'changing the factory layout'. Simple but effective it was one of the major 'initial wins' of the project.

With reference to the original aims of the KTP project we can record a definite success on all of the original aims – to an extent.

Research and then apply TQM or appropriate techniques toward the elimination of quality issues. – A definite **success** in terms of the application of appropriate change strategies and the overall reduction of failures and returns across the range of products.

Research new materials and methods for production, development and testing of new products. – Mainly achieved through the initial change strategies and then through supplier relationships and communications there have been definite successes in this area.

Develop and implement advanced production procedures and processes to maximize output of globally competitive specialist products. The field has been cleared to enable work to be stared on this aspect of the project.

Address a company-wide environment policy need .- Partially addressed and successes in some areas of recycling and reuse.

Be a proactive member of the company's management team.- A definite **success** as the Associate has become a invaluable and essential member of the management team.

The success achieved in meeting the original objectives do not really reveal the true nature of the overall success. At a meeting to review the project the Sales Director commented:

> "(the Associate) has been brave enough to ask awkward questions of the company – questions that had not been answered or even whispered before. We were so busy fighting fires and congratulating ourselves that we could fight fires that we were afraid to ask any questions. We are only now developing this 'questioning culture' and the answers have proved to be more than we had hoped for."

11 Conclusions

The project has been success in that the company has been transformed over the two years from a fire-fighting, hand-to-mouth existence into a structured, proactive, quality conscious operation. The application of various TQM techniques has resulted in immediate improvements and a structured, sustainable approach to quality issues which have beset the company.

Perhaps the most important and significant change within the company has been the cultural and attitude change brought about by the work and example of the KTP Associate. From a position of rejecting any change because it was seen as a threat the culture has changed to accepting change (perhaps not exactly embracing).

The idea of change has now been embedded in the company and is no longer seen as reactive but is now perceived as pro-active.

The economic downturn and changes within the company have been additional hurdles and problems to be overcome. This has obviously affected the project in some ways but in the final analysis it has had little detrimental affect.

Overall the KTP project has been a success. Whilst not achieving all the original aims it has achieved targets which were not even in the original scope of the project – but all in a truly dynamic and real world scenario.

References

Anon, Definition: Customer Centric Approach (2009), `http://www.businessdictionary.com/definition/customer-centric.html` (Last accessed July 4, 2009)

Magnier, P.H.: Value Stream Mapping (2009), `http://www.nwlean.net/toolsCD/VSM/4%20steps%20to%20VSM.pdf` (Last accessed July 4, 2009)

(Agile Manufacturing), `http://www.emeraldinsight.com/Insight/ViewContentServlet?Filename=Published/EmeraldFullTextArticle/Articles/0200240702.html`

Lee, B.: Value Stream Mapping (2001), http://webs.twsu.edu/whitman/papers/lee.pdf (Last accessed July 20, 2009)

Brandon, J.: Managing Change in Manufacturing Systems, pp. 23–108. Productivity Publishing, Olney (1992)

Groover, M.P.: Fundamentals of Modern Manufacturing, pp. 3–24, 1033–1043. Prentice-Hall, Jersey (1996)

Kalpakjian, S.: Manufacturing Engineering and technology, 2nd edn., pp. 1–35,1220–1248. Addison-Wesley, Massachusetts (1992)

Stocker, G.: Avoiding the corporate death spiral, pp. 55–58. ASQ, USA (2006)

Roethlisberger, F., Dickson, W.: Management and the worker. Harvard University Press, Cambridge (1939)

Information Management Process Sharing Knowledge at Worldwide Steel Company

Gabriela Alves[1] and Jorge Neves[2]

[1] FEAD - Centro de Gestão Empreendedora, 30140100, Belo Horizonte, Brazil
e-mail: gabriela.alves@att.net
[2] FPL – Fundação Pedro Leopoldo, 33600000, Pedro Leopoldo, Brazil
e-mail: jtrneves@gmail.com

Abstract. This paper aims to present specific features concerning types of information management in the Continuous Improvement area of the Americas Long Carbon sector in ArcelorMittal, the largest steel company in the world. The aim is also learn what the informational resources (products and processes) related to continuous improvement in ArcelorMittal Americas are and describe how the process of managing information related to continuous improvement area actually happens. The methodologies adopted in this research were: a survey, a documentary research and a bibliography search as data collection techniques. The study has conducted a quantitative non-probability research with professionals involved with the processes, products and services improvement from Long Carbon Americas at different management levels. The study was based on theoretical models of Davenport (1998) and Choo (2006) and tried to understand how the efficient management of information can aid in decision making in organizations. The result of documentary research revealed the existence of initiatives throughout the different units in Americas and also revealed corporate tools for information management which could significantly help knowledge transfer. However, none of the corporate programs was presented in solid form in field research, as a recognized program for managing information. The results of field research indicate the need for a structured and formalized model of information management that responds to users in adequate time, while alert to the need for policies that encourage the sharing of information related to the improvement of processes, products and services.

Keywords: Information Management, Continuous Improvement, Improvement of Processes, Products and Services, Steel Company.

1 Introduction

Nowadays just a few organizations can integrate knowledge and strategies. There are several possible explanations for this phenomenon. The more likely one might be related to the fact that the use of the information strategies is much harder than

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 145–156.
springerlink.com

to simply talk about it. (McGee & Prusak, 1994 p.17) For Drucker (2000, p.10), the companies have no choice but to become a company based on information.

Prahalad (1997) believes that a company actually controls its destiny when it has the ability to predict, uniqueness related to its business and ability to share. The companies that have flexibility to react to market changes are more likely to last. Having access of information is not enough. It is necessary to know how and when to use it.

It seems to be becoming increasingly the feeling that world events are rapidly converging to shape a world that is unique, integrated and which influences economic, cultural or any other traditional cross borders very easily. The implications of these changes are significant and affect all spheres of life, providing new challenges for all organizations (Parker, 1998, p.400).

In October 2006, Mittal Steel took over the majority of the shares of Arcelor and the company became ArcelorMittal, the largest steel group in the world.

It is necessary to emphasize that this study was conducted in an environment of growth and optimism in the steel market. Nevertheless, as of September 2008 the world economic scene has changed dramatically and all sectors of the economy have been affected. The economic crisis caused a drop in steel prices worldwide, reduction of new applications and more factories stopped production for a few weeks to reduce inventories. In this scenario, the year of 2009 will be crucial to redesign the way not only of steel industry, but the world economy.

The main objective of this study is to find out the characteristics of the appropriate model for the information management exclusively for the continuous improvement area in ArcelorMittal Long Carbon Americas.

2 Referential Theory

In this paper the theoretical referential was divided in 03 parts: information and Knowledge, the intelligent organization, and information management

2.1 Information and Knowledge

It has been very difficult to delimit the borders amongst the meanings given to data, information and knowledge. Davenport (1998, p.18) presents some characteristics of the three terms in order to make the distinction between them clearer.

According to Nonaka and Takeuchi (1997, p. 64), information is a stream of messages, being the organizational knowledge created from the flow of this information and anchored in the believes of the knowledge owner.

For authors such as Drucker (2000, p.13), information is any data given with relevance and purpose. Data conversion into information requires knowledge. According to McGee and Prusak (1994), information is a key strategy in the organization, a strategic resource equivalent to labor, technology or capital.

Table 1 Data, information and knowledge

Data	Information	Knowledge
Simple observations about the world state	Data endowed with relevancy and purpose.	Valuable information from human mind
Easily structure	Requires unit analysis	Hard to structure
Easily obtained by machines	Requires agreement of the meaning	Hard to capture from machines
Often quantified	Requires necessarily human mesurement	Often tacit
Easily transferable		Hard to transfer

Fonte: Davenport ,1998, p.18

2.2 The Intelligent Organization

Why do we speak so much about smart organizations? How could we determine whether an organization is smarter than another? Could we perhaps classify them according to its profitability?

Moreover, Garvin (2000 P.54-72) believes that successful organizations manage efficiently their process of learning. According to the author, a smart organization is an organization that learns and is able to create, acquire and transfer knowledge.

According to Edmondson (2008), most executives believe that efficient execution of their processes by production at the right time and in time delivery of products and services is the best way to achieve customer satisfaction and financial results. The reality is a little different. Even the most perfect performance can not assure enduring success in the knowledge economy.

The author proposes four stages for execution with a focus on learning: to provide guidance to the process, to provide tools that allow employees to collaborate in real time, to collect data and to establish a process of disciplined reflection.

According to Leonard-Barton (1998, p. 20), the departure point for a company to manage its knowledge is to understand its strategic skills, which represent a competitive advantage that is not easily imitated. They can provide a permanent advantage over competitors.

Choo suggests that the survival of businesses depends on their ability to process information about the environment and transform them into knowledge that enables them to adapt to change. This skill to adapt is a smart organizational characteristic and it is the key to have an intelligent organizational behavior in an environment of rapid changes. (Choo, 2002).

2.3 Information Management

Only when the information management is done knowingly and seen as a natural process, the organization will actually be based on information (McGee & Prusak, 1994). For these authors, information must be mapped, identified, categorized, and finally released. Firstly it must be identified what to be collected.

There is no right or wrong style, but the style most appropriate to the time the organization is experiencing. In one organization, several types of information management can co-exist.

Davenport (1998) described a generic process of managing information. According to him, each organization can set its process in a different way, with different stages.

1. Determination of requirements
2. Capture which has three different activities: exploration of the environment, classification of information and formatting. –
3. Distribution
4. Use

According to Davenport (1998) in order to improve the management of informational processes, we must emphasize the need for constant improvement of people and inter-related processes.

Choo (2006, p. 403-404) sees the process of managing information as a continuous cycle of six related cases. According to Choo (2006), information management should be viewed as the administration of a network of processes that acquires, creates, organizes, and distributes the information.

The efficient use of information is what Choo (2006, p.404) calls for adaptive behavior: a selection of actions directed at specific objectives.

Choo (2006) analyses each case from the perspective of the information administration whose responsibility is to plan, develop systems, services, processes and information resources.

1. Information needs identification: information is needed to reduce the ambiguities that indicate changes in the environment.
2. Information acquisition: it requires a plan to collect and share information by the organization sources.
3. Storage and information organization: it reflects how the organization notices and represents its environment.
4. Products and services information: it must meet the need of information of the organization members.
5. Information Distribution: The way information is disseminated and how it will be in the right place, right time and right hands.
6. Information Use: It is a result from the sense building, knowledge creation and decisions. In each case, the use of information is a social fluid and reciprocal process.
7. Adaptive behavior: the Company reactions interact with the other companies' actions and thus generate new signs and messages, keeping new cycles of information use.

The organization needs not just to interpret the environments, in which it is inserted, but to create, acquire and transfer new knowledge, changing the behavior before the decision-making process. "The key to understanding the organizations as information systems is to recognize the two anomalies that face all organizational activity: uncertainty and ambiguity" (CHOO, 2006, p. 417).

3 Research Methodology

The research was conducted by quantitative approach. It was applied and descriptive. Descriptive is proposed for further description of the real company area by studying the information management products and processes in this area. Applied is proposed to study a specific problem, the information management in the continuous improvement area in ArcelorMittal Americas.

To conduct this research, aware of the high geographical dispersion of the target population and the wide availability of information concerning key personnel of each unit in relation to information management, it was decided to hold a non-probabilistic sample. Thus, the search for this sampling plan was as follows:

Population: CEOs (Chief Executive Officer), Coos (Chief Operating Officer), VPs (Vice Presidents), Managers and Continuous Improvement professionals involved.

Sampling framework: continuous improvement, and development area's employees of the Americas Long Carbon units.

It was adopted in this research: survey method, documentary research and bibliography search as data collection techniques.

The research instrument selected was the self-administered questionnaire, the questions were arranged to ensure no induction of certain patterns of response.

Ninety invitation letters were sent out by e-mail with a link to a specific site in internet for them to answer a questionnaire. 57% or 51 people from the management level answered the research and all data were analyzed on the basis of theoretical models of information management trough Minitab, statistic software.

To ensure reliability of data, the questionnaires were made available through an internet site created specifically for this study. There was no identification of the interviewee whatsoever and the data was treated in total confidentiality.

After data collection, data were coded, categorized, classified, tabulated and had distribution of frequency defined. After entering data in the software and tabulation of these, descriptive analysis is followed by tables. We used unvaried analysis, by variable and analysis of associations between the variables.

3.1 Company Characterization

With strategically located plants, ArcelorMittal is present in 60 countries with over 330 thousand employees, an annual production capacity of 130 million tons of flat, long and stainless steel, which represents more than 10% of total steel manufactured in the world. In 2007, sales were over 30 billion euros and leadership in main markets: automotive, construction, appliances, packaging and industry in general, especially in the research, development and technology.

The research focused in the study of information management at the Americas ArcelorMittal long steel segment (LCA Long Carbon Americas) continuous improvement area.

The main objective of this area is to diagnose process, product and services' opportunities as well as to develop projects targeting on production increase or cost reduction.

4 Results

During the documentary research, several management information initiatives among Long Carbon Americas units were detected. Each plant is looking for the best way to manage its information using the tools available or creating new tools.

One of these initiatives is the Corporate Information System Management ArcelorMittal Long Carbon Americas (SIGA). It is the management information system used by the LCA that allows the monitoring of companies performance within LCA in Brazil, Argentina, Costa Rica, Mexico, in Trinidad and Tobago, Canada and the United States from its monthly management reports.

Worldwide the company uses BPM software (Business Performance Management), but for some specific reasons LCA works with the information in the SIGA before sending it to BPM. With SIGA system deployment there was an integration of all the information tools and systems, before dispersed in different systems and reports. The software now works as the main information repository on LCA management and it is used by all LCA units.

Other initiatives are the Global Cost Benchmark - GCB and Global Technical Benchmark - GTB. The objective of both databases is to standardize, collect, analyze and distribute comparable information across all units in the company. The first is focused on costs and the second on technical indicators.

The GTB uses the same kind of platform the GCB does, but besides the GCB tools, the GTB team developed SHARE, a problem solving software. SHARE, unlike the SIGA and the BPM, is oriented to the monitoring of technical indicators.

SHARE's main function is to support the units to carry out technical benchmark, identify the indicators that have greater process impact. Data from SHARE respect the same taxonomy, measure units and calculation methods. The units are encouraged not only to feed their data into the system, but to use the software for procedure analysis, and use the data as a platform for planning their performance improvement.

SHARE relies on an assistant program that analyzes the data and presents a pareto graphic with a descriptive statistic summary. The software is a technical information repository as SIGA is a management data repository.

Another initiative is a corporate community called KMP - Knowledge Performance Management, which acts as practice community or as large groups to exchange best practices. There are groups or KMP communities formed to discuss the various metallurgical processes. These groups have representatives from all

ArcelorMittal units and they have meetings periodically. The papers presented during these meetings are published in the KMP SharePoint.

The SharePoint concept is that knowledge is only valuable when it is available. SharePoint, GTB and other information repositories are concentrated in a single portal called Global Knowledge Management Program. (FIGURA 1).

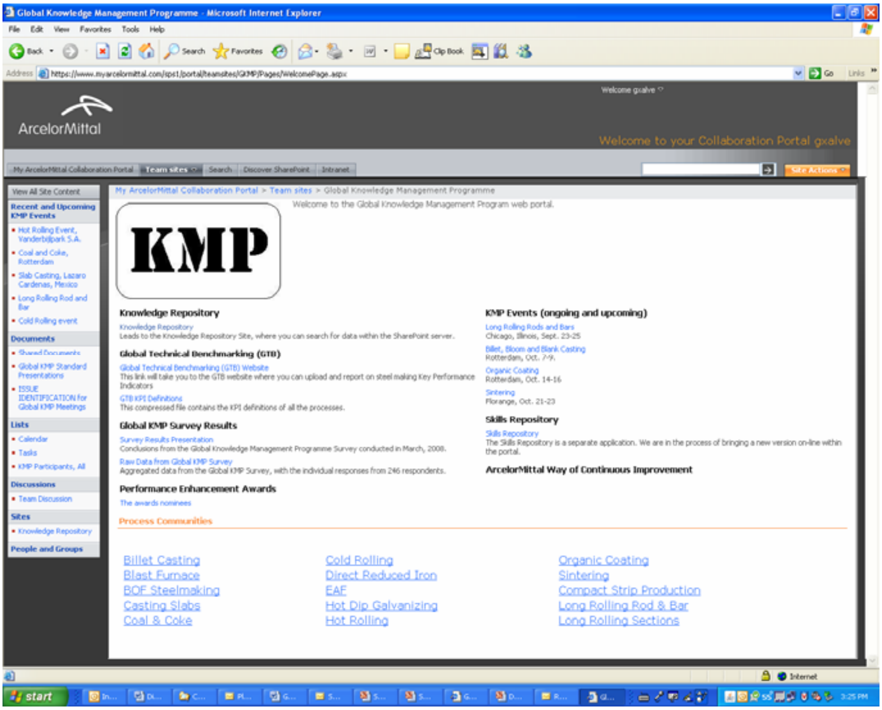


Fig. 1 SharePoint Screen
Source: Company's intranet.

SharePoint is the main tool available throughout worldwide to increase knowledge sharing. All ArcelorMittal employees have access to the data stored in the Knowledge Repository. It is possible for the community owners to create restricted access sub sites for data they consider sensitive, but it is discouraged. It is the responsibility of the community owner to motivate the individuals to upload information relevant to that community. The success of the community relies heavily on the interest of the community owners in driving this process. Once there is enough information available, people search and fine answers to their questions, they will be more interested in sharing information, growing the content, and transfer knowledge.

The survey was conducted from September 11^{th} to October 7^{th} 2008 with professionals linked to product, process and service improvement from LCA. The response rate was 57% (51 questionnaires). This rate was satisfactory considering the motivational efforts made and the occupational level of the people selected to enroll the survey. Regarding the spot check, 61% of respondents are between 36 and 45 years old, 90% are male and 63% have an academic background in engineering.

The perception of 65% of the respondents is that the company has a formalized process as far as strategic information management. However, the answers point that the information management process is emerging and has some improvement opportunities.

This study adopted the Davenport (1998) generic information management model; it was used as a basis for the questions formulation and the grouping of responses.

The data indicates a difficulty in defining which the information clients' demands are. About 51% of respondents characterized the process of determining of information demand as informal or nonexistent. 49% of respondents characterized this process as structured and 60% of respondents agreed that people who generate the information are aware of their target audience and objective.

The information obtaining process requires time, skill, insight and continuity. The research results show that in LCA, the search for information related to processes, products and services improvement is conducted in an unsuited manner. Approximately 57% of respondents rated as inappropriate for the time spent collecting information.

To learn where to find the information is very important although not enough to get it. A process for efficient search and retrieval of information begins by defining the terms of taxonomy, classification and archiving to enable rapid and efficient consultation for users. At the junction of the variables only receive the necessary information and the awareness of which to search for information, statistics were not significant. 70% of respondents disagreed with the statement that they only receive useful information.

After setting, finding, sorting and formatting the information, you must deliver it to its destination. Getting the right information, at the appropriate time and the user who needs it are the steps to optimize the use of information. A well-prepared information in the hands of those who do not need it, it is a waste of time and effort.

Approximately 86% of respondents do not recognize a policy direction for the distribution of information. Data from research shows that the management information efficiency is linked to the existence of management information practices.

According to Choo (2002) the ultimate goal of distribution and dissemination of information is to facilitate its sharing. Below data from research (Table 2. and 3) shows that the respondents recognize the need to share information within the unit and among units, but 75% of respondents have from very small to medium degree of willingness to share information ranging.

The data research however, does not allow us to identify the cause of this phenomenon, but it suggests that some factors may contribute to the low interviewee's availability to share information, such as low efficiency in the provision process, products or services improvements in the unit, lack of encouragement policies to information-sharing and no lay-out to promote information exchange.

Table 2 Employees' opinion about how the knowledge should be shared

Sharing	*Frequency*	%
Only within the unit	2	3.92
Among units	5	9.80
Within the unit and between units;	44	86.28
Total	51	100.00

Source: Research data

Table 3 Employees' availability for sharing technical information

Sharing availability	*Frequency*	%
Very little	2	3.92
Reduced	13	25.49
Middle	23	45.10
High	13	25.49
Total	51	100.00

Source: Research data.

Until the complete and efficient information is inert if not analyzed and used by the user. It is at this stage that the information comes alive, or rather, it gains sense and helps those who use it in the decision making process.

Although 82% of people agreed that there is the formal implementation of actions to improve the use of information, 70% of respondents identified personal contact as the main way to get the information necessary for these process improvements. The data does not allow us to conclude the reason why they prefer the personal contact. Meanwhile, another data revealed that 94% of respondents agreed that a centralized system for the exchange of best practices would facilitate the work of all.

With a centralized system or not, the company needs to make the information flow and find the best path to an effective use. The data showed statistical significance of the research associated to the variables efficiency of information management and the existence of procedures for the managing information process. What allows us to conclude that an important step in LCA information management process is define procedures for its operation. The system will only be characterized and noticed by users as structured and formal, then the process of standardizing the management and dissemination of new procedures to its users.

From the correlation analysis, four new variables combined were generated. However, it appears that the two most important variables combined carry about 64% of the information of the original system. This indicates that the relationship could reasonably be translated through these two new variables, reducing the size of the original system of four to two.

According to the analysis it was found that the characteristics associated with higher overall efficiency of a managing information system for the interviewees are the speed of response and formalization of the structure.

The use of knowledge and the file organization appears as issues related to both standards, efficient and inefficient, however were not decisive for the classification system of information management.

5 Conclusions

The research's main goal was to set out what are the features of the appropriate model for the management information at the continuous improvement area in ArcelorMittal Long Carbon Americas.

The research data showed that management information to processes, products and services improvement efficient in LCA has two main features: it is a formalized process and it must have quick response in information search.

Despite several initiatives towards the information management nowadays, most respondents do not have a clear vision of where to get the necessary information; they recognize the rework and have medium level of willingness to share information. Data from research shows that although the respondents still prefer to share information internally, they are willing to share information as long as the system is structured and formalized.

SharePoint is the initiative with the greatest potential to become a global ArcelorMittal tool for official information management activities. For the SharePoint to become something more than a information repository, research data allows us to conclude that there must be a structured process of information management as a whole. The process must be formalized, standardized and official with clear procedures which should be disseminated throughout the company.

Research data also showed that respondents use personal contact as main source of research and information exchange, having e-mail as their most used tool.

These figures lead us to conclude that for technical information to be disseminated, personal contact is very important. A tool that can help the dissemination and sharing of information is the practice community where the members can meet regularly in person or through video conference.

To lay out all the information available for improvements that are being or will be developed is still an idea that may not please people involved in the development of new products, for instance. Thus, the community members should be accepted by the responsible member, and his stay may be subject to its contribution for the group.

References

Argyris, C.: Double Loops Learning in Organizations. Harvard Business Review (September-October 1977)

Auster, E., Choo, W.: How Senior Managers Acquire and Use Information in Environmental Scanning. Information Processing & Management 30(5), 607–618 (1994)

Barbosa, R.: Inteligência Empresarial: uma avaliação de fontes de informação sobre o ambiente organizacional externo. DataGramaZero, Revista de Ciência da Informação 3(6) (2002), http://www.dgz.org.br/dez02/F_I_art.htm (Access on October 2007)

Benzecri, J.P.: Sur le calcul des taux d'inertie dans l'analyse d'un questionnaire. Cahiers de L'Analyse des Données 3, 377–384 (1979)

Choo, W.: A Organização do conhecimento: como as organizações usam a informação para criar significado, construir conhecimento e tomar decisões. Editora Senac São Paulo, São Paulo (2006)

Choo, W.: Information management for the intelligent organization: the art of scanning the environment. Information Today, Inc., Medford (2002)

Davenport, T.: Ecologia da Informação: por que só a tecnologia não basta para o sucesso na era da informação. Futura, São Paulo (1998)

Davenport, T., Prusak, L.: Conhecimento Empresarial: como as organizações gerenciam o seu capital intelectual. Campus, Rio de Janeiro (1998)

Drucker, P.: O advento da Nova Organização. In: Gestão do Conhecimento. Harvard Business Review, Afonso Celso da Cunha Serra, Tradução. Campus, Rio de Janeiro (2000)

Edmondson, A.: The competitive Imperative of Learning. Harvard Business Review 86(7/8) (July-August 2008)

Garvin, D.: Construindo a Organização que Aprende. In: Gestão do Conhecimento. Harvard Business Review. Tradução: Afonso Celso da Cunha Serra. Campus, Rio de Janeiro (2000)

Garvin, D., Edmondson, A., Gino, F.: Is Yours a Learning Organization? Harvard Business Review (March 2008)

Greenacre, M.: Theory and applications of correspondence analysis, p. 364. Academic Press, London (1984)

Lebart, L., Morineau, A., Warwick, K.M.: Multivariate Descriptive Statistical Analysis: Correspondence Analysis and Related Techniques for Large Matrices. J. Wiley & Sons, New York (1984)

Leonard-Barton, D.: Nascentes do Saber. Fundação Getúlio Vargas, Rio de Janeiro (1998)

Lopes, M.: Panorama do Desenvolvimento da Siderurgia Brasileira. Instituto Brasileiro de Siderurgia (2007), http://www.abmbrasil.com.br (Access on November 2007)

McGee, J., Prusak, L.: Gerenciamento estratégico da informação. Campus, Rio de Janeiro (1994)

Nonaka, I.: A empresa criadora de conhecimento. In: Gestão do Conhecimento. Harvard Business Review, Afonso Celso da Cunha Serra, Tradução, Campus, Rio de Janeiro (2000)

Nonaka, I., Takeuchi, H.: Criação de Conhecimento na Empresa: como as empresas japonesas geram a dinâmica da inovação. Campus, Rio de Janeiro (1997)

Parker, B.: Evolução e Revolução: Da Internacionalização à globalização. In: Clegg, S.R., Hardy, C., Nord, W.R. (eds.) Hadbook de Estudos Organizacionais. Modelos de Análise e Novas Questões em Estudos Organizacionais. Organizadores da edição original, Organizadores da edição brasileira: Miguel Caldas, Roberto Fachin e Tânia Fischer, São Paulo. Atlas, vol. 1 (1998)

Prahalad, C.: A Organização Reestruturável. In: DRUCKER (org) A Organização do Futuro: como preparar as empresas de amanhã. Futura, São Paulo (1997)

Prahalad, C., Hamel, G.: A Competência Essencial da Corporação. In: MONTGOMERY, Cynthia A.; PORTER, Michael E. Estrategia A Busca da Vantagem Competitiva. Elsevier Editora, Rio de Janeiro (1998)

Yin, R.: Estudo de caso: planejamento e métodos. Bookman, Porto Alegre (2001)

`http://www.asq.org/` (Access on March 2008)

`http://www.fnq.org.br/` (Access on March 2008)

Using Multi-Agent System for Business Applications in Multilingual Ontologies

Anne Håkansson[1], Ronald Hartung[2], and Jason J. Jung[3]

[1] Department of Computer and Systems Sciences
Stockholm University
Kista, Sweden
e-mail: Anne.Hakansson@dsv.su.se
[2] Department of Computer Science
Franklin University
Columbus, Ohio, USA
e-mail: Hartung@franklin.edu
[3] Knowledge Engineering Laboratory
Yeungnam University
Gyeongsan, Korea
e-mail: j2jung@intelligent.pe.kr

Abstract. In e-business, ontology technology is used for e-commerce and e-services. The ontologies are specifications of syntax and semantics of information, which provide a shared vocabulary to facilitate online services. For some requests, multiple ontologies are required to solve a problem, like for e-tourism. However, there are problems with using several ontologies. For example, finding and using the ontologies depends on the language used in the ontologies, and matching techniques. The matching includes word correspondence to the users' request and the equivalence between the ontologies. The matching is difficult due to differences between ontologies resulting from the lack of standards and development guidelines. This paper presents a multi-agent system wherein the agents use the users' request to search for multilingual ontologies. From the search results, the system facilitates communication between the users input and the ontologies to accomplish the request, which can be booking a train ticket or an event. Meta-agents keep track of the agents and manage the user-system communication.

Keyword: Multi-agent systems, Software Agents, Meta-agents, Ontologies, Language translation, Matching.

1 Introduction

In e-business, ontologies have been used for different purposes, such as, e-commerce and e-services [2; 7]. The notion of ontologies is an explicit specification of shared conceptualisation, which can be used to model a domain

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 157–166.
springerlink.com

with objects, concepts, properties and relations [2]. By shared vocabulary, the ontologies can be used for online commerce and services. These facilities give the enterprises the possibilities to be competitive by supplying extra-ordinary and additional services and offers. They can also expand the number of customers, both national and international.

For some online user requests, several ontologies are needed to accomplish a task, like in e-tourism. These ontologies can, through the combination of several different ontologies, support travelling in a country and provide possible tourist attractions available within the time span of the trip. For example, booking a flight to a foreign country usually requires booking a hotel at the site and sometime also other bookings like travelling within the country and events, such as theatres, musicals, concerts, operas, circuses, museums, and sport events. An automated system can provide significant business value by providing opportunities to the traveller, which can be new or additional information to the traveller that otherwise would be unaware of the offering.

However, since these online bookings concern local events, the web sites usually are in the local language and may, therefore, not be understandable for foreign travellers. Hence, we need a computer system, which can handle bookings in foreign language. The system needs to handle problems with, finding, using and combining several ontologies. This includes searching the ontologies, translating between several languages, and matching the terms (i.e. labels of the elements) of the ontologies. Searching the appropriate ontologies requires finding the ontologies that correspond to the users' requests and deliver information about the ontologies. The result from the search is limited due to the language of the ontologies. Many are written in English, but others are in other languages, like Swedish and Korean. Therefore, if the request is not written in English, it must be translated both into English and the language of destination country. Moreover, to work with the multilingual ontologies, the ontologies need to be matched, which is accomplished by using matching techniques such as Jason *et al.*, [12] that have been extended to include the multilingual dimension in the mapping. Also, if several ontologies are used for a tourist trip, these ontologies also need to be matched. An example is the time frame where an event must occur at the same time the trip takes place.

This paper presents a multi-agent system that receives a user request and searches for ontologies in language of the destination country. The agents in the multi-agent system find the ontologies that correspond to the request and return the links and paths to the ontologies. More specifically, the agents are required to find one ontology each and bring back the location of it, which they do in parallel. The agent also acts as the interface to the individual ontologies. Then, the system supports filling in the missing information to complete the task.

Since there will be multiple agents searching for ontologies, we need a facility to coordinate them, i.e., meta-agents. These meta-agents can uphold communication with the users by keeping track of the information that need to be inserted. The meta-agents perform the mapping between ontologies and language translation. Moreover, the meta-agents can reason with the contents of the ontologies to make sure that they correspond to the users' request.

2 Related Work

There is a body of work on building e-business systems with agent systems. These include negotiation and user preference, as well as, general agent approaches to e-business [14;10;16].

Commonly, multi-agent systems use ontology solutions to drive the internal operation of the agents systems [7; 11]. In these systems, ontology is used to define communication between the agents with providing a concept domain. Ontologies are sometimes used to communicate between disparate systems. This brings in the problems of mapping ontologies and language translation issues. The language in the ontologies is information specific to a locale and is in the locale's language. This is addressed in Jung et al [12] who present an approach that uses a manual component to map multilingual ontologies. Our ambition is to automatically make the mapping.

For business process with ontologies, there are two interesting approaches. In Hartung *et al* [9], the ontology is used to extend a system modelling methodology called RED. RED is used to model a business process into a set of transactions. The second approach is described by De Bruijin *et al.*, [2] that uses standard ontology construction to define business processes. For our system, the business processes comprise a known set, various booking processes and additional processes to support search and present the user with options for booking services. Although we envision moving to a more dynamic view in the future.

To our best knowledge, no MAS with agents and meta-agents is used to search for multilingual ontologies and match these to support tasks that indirectly support improved business value by offering the user opportunities beyond the direct requests.

3 Ontologies with Business Processes

Ontologies can form a vocabulary with a formal and explicit specification [2]. Such a specification is critical to systems that provide automated reasoning and search in the e-services and e-business. Current practice is based on the user providing the intelligence to carry out the tasks [6]. Ontology can construct a model of the services and the actors that make up the domain being serviced.

To automate the business processes at a level that achieves the full potential of e-business, multiple significant constituents need to be modelled. These constituents include vocabulary, business processes and business protocols [2].

In our work, the vocabulary has two main dimensions. The first is language: In a system that services world-wide travel, information specific to a locale will often be in the locale's language [12]. A second dimension occurs when used by the traveler system to help the tourist. While some event types in the ontology may be universals, concerts for example, other events may be rather local in character. We can employ local ontologies to find vocabulary of events that can be classified as having tourist value.

Business processes define the business activities in a domain [2]. In most e-business systems, the business process is encoded in the programs. This works for systems that remain relatively static. In our system, there is a gain using the ontology to define the processes. The business processes comprise a known set of various booking processes and other processes to support searching and presenting options for booking services and are expressed in ontologies.

Business protocols describe the implementation of the externally interactive parts of business processes, i.e., the parts of the business process that require the system to interact with external systems. The parts that work internally tend to be fixed and well known. Since our system must function with a large and unknown set of external services, the interaction part must work with dynamic rather than unknown business process. Business protocols solve the problem of booking events or making reservations but may require variations specific to locale. Hence, each protocol defines the specific details of interaction between the parties to achieve the business process. The handling of business protocols will be more challenging than the vocabulary issue since the business protocol is an active process. As active processes must execute correctly, they are prone to failure.

For a single enterprise, a single ontology can serve the business. The system can use this internal single ontology to drive the processes by using initial basic defined vocabulary. For external enterprises, several ontologies are used and the search system must locate the ontologies and work across vocabularies to effectively find the services to be offered to global travellers. This introduces several complexities: the ontologies must be selected by suitable criteria to ensure relevance to the problem; the ontologies must be placed into proper correspondence with each other using dynamic mapping.

Since, we do not need totally map, or match, the ontologies, there are a variety of mapping techniques [4]. We use the approach proposed by Hartung [8], which uses argument systems and meta-level agents to form valid mapping across multiple ontologies. In this system, a simplified version of the algorithm will work, since mapping is mostly done on simple pairs. It is a direct mapping with some semantic handling. However, the approach works well here as the mapping can be partial mappings, saving time over complete mappings.

4 The Multi-Agent System

The multi-agent system (MAS) includes software agents and meta-level agents. The agents in MAS work with external environment to accomplish assignments. The software agents perform tasks independently and without any authorised control of the performance or user involvement [15]. Thus, the agents need to be capable of autonomous actions, situated in different environments [17] where the agents independently search for the ontologies and return with the ontology locations.

The assignment for the agents is searching and finding information at the extranet, which is a difficult task environment [1]. The environment is partially observable, stochastic, dynamic, continuous, and episodic.

The environment is partially observable since some of the information is known but since the environment can continuously grow, it will almost always contain new information. The agents are working with ontologies to solve tasks both within the MAS and on the extranet. Even though we consider the environment to be partially observable, the agents must still be able to find the significant information needed for finding solutions. Finding the necessary ontologies corresponds to fully observable environment, where the agents can obtain complete, accurate and up-to-date information about the environment state [17].

A partially observable environment with stochastic elements [15] is what will be expected for our agents. The agent cannot predict the behavior of the environment, as in real-world cases, since the states, which will result from performing an action, is unclear. Even though the environment is deterministic, there will be stochastic elements, web sites that randomly appear. The agents have a task of searching and mapping ontologies but the information and combinations will vary with time when actions these are performed.

While agents are deliberating the contents, the dynamic environment can change [17; 15]. In these dynamic environments, the agents need to interact with the environment and continuously check the surroundings to act properly. This characterizes the extranet since the environment changes on a daily bases. However, the environment might be static over shorter time intervals while the agents consider their course of action between states. Nonetheless, changing environment can affect the agents and make them monitor the environment for each task.

Continuously working agents can be a problem since there might be uncountable number of states and actions arising from the continuous time problem [17]. This requires special treatment of the agents using execution suspension to control the agents' performance so they do not continue to search endlessly. Commonly, the suspension of execution occurs when the agents have found information and returned with a result. This can limit the possibility of finding several solutions. A better solution in our system is an execution suspension for a time interval, which is followed by a resumption of the search.

The choice of action in each episode depends on the episode itself [15]. While the agents are moving between commercial sites finding information, they perform one task at the time. The call to the MAS can be more complex, but before the task is assigned to agents, the call is divided into smaller, single parts, where each single part is applied to an agent. Hence, a number of agents will be used to perform a task. From the users' request, the agents search for ontologies. The agents select ontologies according to criteria in the call, so they are useful to the process. The software agents have following structure:

$\forall$ Agents(x) (From Node, To Node, Ontology Id, URL (path), Alignment).

Multiple agents are used in order to collect ontologies into groups of related topic areas. For example, train ontologies in the locale language, or ontologies for tourist activities in a locale.

The purpose the agents is to deliver the locations and paths to the ontologies. This facility make it easier to refresh the ontology, i.e., if it is needed for further consultation. The path is stored when the system find the ontology useful for the task. When the system has decided that the ontology is useful for the assignment, the path is used for communication with the user. The ontology is examined to find the slots that are needed to be filled in to complete the task. When the ontology is fulfilled, it completes the transaction. If not, another ontology must be tried out with the same information. If the first case occurs, everything would be completed without any problems. If the latter occurs, the communication must proceed without disturbing the user and automatically inserting the information in the slots and check if the ontology can perform the expected task. If the users are satisfied with the range of found ontologies, the paths are placed in a queue of successful paths, i.e., if the ontologies are reasonable and successful according to the request. Otherwise, if the users are not satisfied, the search paths are disregarded.

Although an agent has found an ontology, several other agents will search for similar ontologies. This will continue until the user is satisfied with the ontology and the delivery is met. Because of this facility, a vast number of agents are required to search for ontologies. To keep track of the agents, ontologies and results produced from accomplishing tasks, meta-level agents are applied. These meta-level agents are also used for matching the ontologies and reasoning with the contents.

The meta-level agents, also called meta-agents, are used for meta-reasoning, similar to Chelberg *et al* [3], where the meta-level is at more abstract level than the software agents. Meta-reasoning is a technique that supports the system to reason about its own operation. The reasoning can be used to reconstruct the agents' behaviour [13], and keep track of agents at lower level of abstraction. The meta-reasoning can be applied in the implementation strategies or plans to respond to requests [5] but also to reason about the contents of the ontology. Besides reasoning the meta-agents can plan actions and maintain individual agents' state information, as well as, attempt to control future behaviour, classify conflicts and resolve these conflicts [5].

The meta-agents are assigned to keep track of all the agents that are searching for ontologies. The number of agents will be just as many as found ontologies. Since there might be several hundred, the meta-agents provide an overall view and structure of the agents, constituting a hierarchic structure on top of the agents, where the agents are the leaves and the higher-level and more abstract nodes are the meta-agents.

The meta-agents are built on the agents' performance. Thus, when an agent has successfully performed a task, a meta-agent is built as a copy of the agent's location path to the ontology. By this facility, we will have many meta-agents with the locations to the ontologies. The meta-agents have following structure:

$$\forall \text{ Meta-agents}(x)\ (\text{Ag}1,\ldots,\ \text{Agn}).$$

The communication is simple investigation of the ontology to check the slots values. Information about the slots in the ontology that are not set to a value will be brought back to the user, who needs to provide the missing information. Before completing the task of make reservations, the user has to conform the information. Also the ontology needs to be checked by the providing company to make sure that correct information is provided. For example, the time interval of traveling is an important part, as well as, information about the traveler and payment.

The ontologies used for a trip can be written in different language and, therefore, a domain vocabulary is needed. The matching, for the moment, is a simple word translation but to make the translation automatic, we need a context covering tourists' contexts. The contexts require at least semantic information of the words. All the semantics of the user inserted keywords will be used for the matching. The matching will be made without the users' involvement but in some cases, when the matching does not work, the user will be able to choose a matching that best suits the task.

The meta-agent's reasoning, with the contents of the ontologies, is to induce the purpose of the ontology. Many ontologies can include the keywords that correspond to the user's request but not many of them may be used to accomplish the task. Reasoning is used to find the base words of the ontology and put those in the context of the task domain. When comparing the content of the ontology with the context of the request, it is possible to infer the usefulness of the ontology. For example, a match of trips, booking and Korea, can either be a story about a trip that somebody made or trip booking. The induction of the words can support finding the useful ontology.

4.1 Architecture

The MAS can be placed at the company but works externally with the web. The web acts as a source for ontologies that can correspond to the request. The system will also contain standard ontologies designed in for the domain, e.g., e-tourism. The architecture of the system is presented in Figure, 1.

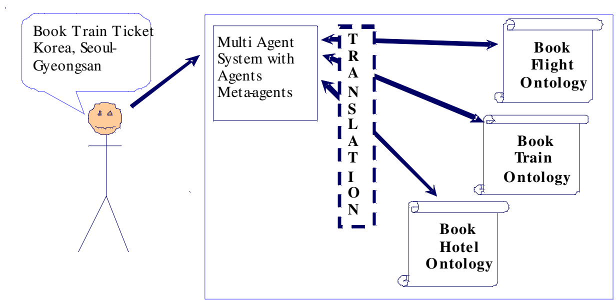


Fig. 1 Architecture of the multi-agent system

The users launch the system by a request. The MAS will first check for earlier communication. If any matching event is found, the system will search for the ontologies used and, if needed, (and most likely) ask for more information. If a user has travelled before, some information might be stored already, e.g., addresses, work, email addresses, telephone number but the location and the dates of the trip will, most likely, are new.

If information is not found in the MAS, the system needs to look for additional ontologies with corresponding keywords. The task of the MAS is to translate the request to the language of destination country and find all the ontologies according to the request, see Figure 1. Those ontologies do not necessary have to be written in the language of the destination country. Instead it will be possible to find some in third language, often English, then the system must make the request in the traveller's language and the destination language using English as an intermediate. It is possible to find not only the target task but also complementary ontologies. Thus, for booking a trip, the MAS can also suggest possible hotels, trips and events which take place at the time for travelling.

5 A Scenario

To illustrate the work with MAS and Ontologies, a scenario is presented. A user situated in another country, that is going to travel by train in Korea, wants to make reservations for the ticket. The user begins the session by calling the MAS with the words "Boka Tågbiljett, Korea" (book train ticket, Korea) and the system translates the call into Korean to start searching for the web sites using a search tool like Swoogle.

Since some web sites have ontologies attached to the site, Swoogle can directly locate ontologies for search terms. Terms alone can have overloaded meanings and will result in bad search terms from ontologies outside the desired domains, so domain checking is required. The ontologies then contribute to an expanded set of search terms to look for the actual desired information.

When the system finds the web sites, it can, together with the user, decide which one is most appropriate for train travelling. The system looks through the chosen ontology and will, most likely, find not filled-in slots. The information is translated back to Swedish and the system asks the user about it, in this case "Från" (Departure) and "Till" (Destination). The user fills in the information, Seoul and Geyeongsan, and marks the dates for travelling. These are matched with the availability of train tickets and, if everything is ok, the system takes care of payment and sends an e-ticket or a paper ticket.

Currently, the translation is made in a word by word mode, using Google translation, from Swedish to Korean, see Figure 2. The more keywords of the request the ontology contains, the stronger the matching and the more likely the ontology will be used for interaction. Thus all the keywords in a request should be present in the ontology. The matching technique shows the alignment between ontologies.

Several providers of ontologies will be found. If the trains are commercialized there might be several ontologies. Otherwise, and most likely, there will be only one ontology. In the case of finding information about events, the system has to search all the ontologies. There will be a much larger degree of variation with these ontologies from which the users can choose one or more events.

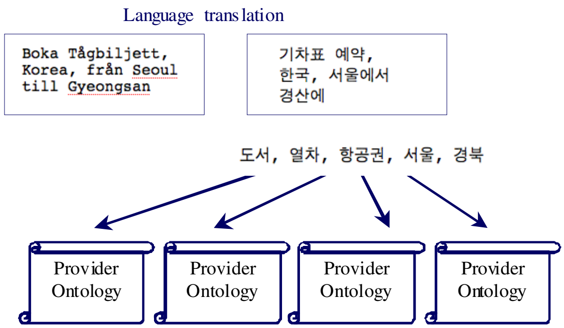


Fig. 2 Language translation for book a train ticket, in Korea, from Seoul to Gyeonsan

6 Conclusion and Further Work

In this paper, we presented a MAS where the agents are used for searching for e-service ontologies, which are used as specifications for tasks within a specific domain, like e-tourism. Since the users' communication and the ontologies can be written in different languages, translations are needed into the language of the destination country and English. For this work, we used simple Google translation. The agents search for the ontologies, matching keywords with alignment technique and return the results and paths to these ontologies. To keep track of the agents, ontologies, and paths, meta-agents are used.

The MAS system with agents and meta-agents exists but it is still at a primitive level. The translation must be handled by a smoother tool since Google translation stores the Korean letters in images. The translation can use its own ontology containing words of the domain. Moreover, the system needs profound testing before commercializing it.

Acknowledgement. This work is supported by Sweden-Korea Research Cooperation Programme funded by STINT, The Swedish Foundation for International Cooperation in Research and Higher Education. http://www.stint.se/

References

1. Apelkrans, M., Håkansson, A.: Information coordination using Meta-Agents in Information Logistics Processes. KES (3), 788–798 (2008)
2. De Bruijin, J., Fensel, D., Keller, U., Lara, R.: Using the Web Service Modeling Ontology to enable Semantic eBusiness. Commnications of the ACM 48(12) (2005)
3. Chelberg, D., Welch, L., Lakshmikumar, A., Gillen, M., Zhou, Q.: Meta-Reasoning For a Distributed Agent Architecture (2000), `http://zen.ece.ohiou.edu/~robocup/papers/HTML/SSST/SSST.html`
4. Choi, N.: A survey on ontology mapping. ACM SIGMOD 35(3), 34–41 (2006)

5. Costantini, S.: Meta-reasoning: a survey. In: Kakas, A., Sadri, F. (eds.) Computational Logic: From Logic Programming into the Future: Special volume in honour of Bob Kowalski (in print). Springer, Berlin (2002)
6. Flett, A., Brown, M.: Enterprise-standard ontology environments for intelligent e-business, http://www.csd.abdn.ac.uk/~apreece/ebiweb/papers/flett.pdf
7. Gordijn, J.: E-Business ontology (2001), http://www.cs.vu.nl/~obelix/D5.1.pdf (2009-03-29)
8. Hartung, R.L., Håkansson, A.: Using Meta-agents to Reason with Multiple Ontologies. In: KES-AMSTA 2008, pp. 261–270 (2008)
9. Hartung, R.L., Ramanathan, J., Bolinger, J.: Ontology for Enterprise Modeling. KES (3), 799–807 (2008)
10. Helal, S., Wang, M., Jagatheesan, A.: Service-centric brokering in dynamic e-business agent communities. JECR, Special Issue in Intelligent Agents in E-Commerce (2001)
11. Jenz, D.: Ontology-based Business Process Management (2003)
12. Jung, J., Håkansson, A., Hartung, R.L.: Indirect Alignment between Multilingual Ontologies: a Case Study of Korean and Swedish Ontologies. In: KES-AMSTA-2009, Uppsala Sweden, June 3-5 (2009)
13. Pechoucek, M., Stepánková, O., Marík, V., Bárta, J.: Abstract Architecture for Meta-reasoning in Multi-agent Systems. In: CEEMAS 2003, Prague, Czech Republic, June 16-18 (2003)
14. Purvis, M., Nowostawski, M., Oliveira, M., Cranefield, S.: Multi-agent interaction protocols of e-business. In: IAT 2003, October 13-16, pp. 318–324. IEEE/WIC (2003)
15. Russell, S.J., Norvig, P.: Artificial Intelligence: A Modern Approach. Prentice Hall, Upper Saddle River (2003)
16. Shin, H., Bo-Yeon Shim, B.: e-Business Agent Oriented Component Based Development for Business Intelligence. In: Gabrys, B., Howlett, R.J., Jain, L.C. (eds.) KES 2006. LNCS (LNAI), vol. 4252, pp. 803–811. Springer, Heidelberg (2006)
17. Wooldridge, M.: An Introduction to MultiAgent Systems. John Wiley & Sons Ltd., Chichester (2002)

Facilitating Knowledge Transfer to Drive Innovation in SMEs

Ileana Hamburg[1] and Mihnea Marin[2]

[1] Institute for Work and Technology – FH Gelsenkirchen, Germany
e-mail: hamburg@iat.eu
[2] University of Craiova, Romania
e-mail: mihmarin@yahoo.com

Abstract. Small and medium sized companies (SMEs) need to be innovative in order to survive in or to integrate into the international market. Survival and integration depend on the deployment of their knowledge environments/bases, on the acquisition and creation of new knowledge, on learning abilities and the efficient use of new technologies to manage internal and external knowledge flows. In this paper we firstly present eLearning which has the potential to support knowledge sharing, creation and transfer of individual and organisational knowledge through interactive methods of on-line delivery of information, collaborative procedures, targeted training and through blending with other education methods. Secondly we briefly describe Communities of Practice (CoPs) as proper environments for groups aiming at creating and sharing knowledge and solving practice problems and which can be used to facilitate the informal transfer of knowledge that drives productivity and innovation. We give as an example a project where we use eLearning 2.0 and procedures based on Web 2.0 techniques, to support knowledge sharing, knowledge transfer and networking in CoPs.

1 Introduction

Competition in global markets, economic situations and the development of new technologies are increasingly requiring change in the given patterns of management and facilitation of knowledge. Companies must aim at being innovative in order to survive in or to integrate into the international market. This depends on the deployment of their knowledge environments/bases, on the acquisition and creation of new knowledge, on learning abilities and the efficient use of new technologies to manage internal and external knowledge flows.

The emergence of the Web and Internet facilitates the building of partnerships wishing to cooperate and learn in the generation of knowledge and in the process of innovation. In this context the Communities of Practice (CoPs) are proper environments for groups aiming to create and share knowledge and solve practice problems. They can be used to facilitate the informal transfer of knowledge that drives productivity and innovation.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 167–177.
springerlink.com

The knowledge transfer is considered as an aspect of knowledge management (KM); it is very complex depending on actors, tools and tasks [3]; much knowledge is tacit or hard to articulate [26].

Though knowledge management (KM) is frequently identified as an important antecedent of innovation, very little research has addressed both. The antecedents and consequences of effective KM particularly transfer of tacit one and learning to do it in order to positively affect innovation should be researched.

There is a significant difference in KM practices and innovation between academia and industry. In the academic context the new is often celebrated, whether it is useful or not. Innovation in industry will often draw on lessons from the past, particularly those that have been forgotten, or those that can be put together in combinations to achieve new results. In practice the “newness” of the knowledge is not important; what is, is that it works and can be immediately transferred and applied to innovation.

Small and medium-sized enterprises (SMEs) are socially and economically important but many of them are not ready for significant international social and economic changes [4, 5, 6, 13]. Some SMEs have focused on KM and used it as an enabler for innovation capability, but many of the practiced KM approaches failed. For an SME to manage and sustain business whilst engaging in KM and associated training can be very difficult. Their priority is survival, leading to just-in-time activities; the benefits of KM to the business have to be very clear and measurable. To be effective and acceptable to staff, knowledge management environments and approaches have to be directly related to competencies and activities of the staff on the job [18].

eLearning, particularly eLearning 2.0 based on new information and communication technologies (ICT) such as Web 2.0 [27] can support KM. The term Web 2.0 became notable after the first O'Reilly Media Web 2.0 conference in 2004. It does not refer to an update to any technical specifications, but rather to changes in the ways software developers and end-users utilize the Web. According to Tim O'Reilly (2005): “Web 2.0 is the business revolution in the computer industry caused by the move to the Web as a platform, and an attempt to understand the rules for success on that new platform”. Web 2.0 focus on community and eLearning 2.0 has the potential to support knowledge sharing, creation and transfer of individual and organisational knowledge through interactive methods of on-line delivery of information, collaborative procedures (eCollaboration), targeted training and through blending of eLearning with other education methods. Particularly a more effective transfer of marketing knowledge to firms can be realized through eLearning and eCollaboration.

Results of studies, projects and discussions with SME experts and representatives show that one of the most critical but important aspects to be considered in the context of learning and KM is an evaluation of the readiness of SMEs. Many companies lack an understanding of their knowledge needs and of what they could accomplish with an eLearning effort. They do not have long-term learning strategies and act when needs are “urgent”. Innovative processes are low in many European SMEs also because they have less resources and experience. SMEs do not initiate joint co-operations that can facilitate social interaction and learning in order to harness the value of shared tacit knowledge.

Knowledge-intensive, practice-oriented co-operative environments like Communities of Practice (CoPs) are able to help SMEs in innovation processes. The construct of CoP [31] has been used in different fields including education. In the past few years, CoPs have been associated with KM and people see them as a way of developing social capital, a sharing of existing tacit knowledge by the practitioners, transferring knowledge and stimulating innovation. CoPs offer new opportunities for KM and learning processes through using new forms of interaction in teamwork and loose contact between the actors. They can be considered as innovative tools for a social KM approach. It is assumed that CoPs will be an accepted part of SME organisational development in large companies such as Hewlett Packard, Shell and IBM.

In this paper firstly we give an approach to prepare SMEs for eLearning strategies which support knowledge transfer. We start with an evaluation of the readiness for eLearning. Finally we present CoPs, particularly virtual ones (VCoPs) as suitable approaches to support transfer of knowledge facilitating innovation within SMEs and provide an example of using Cops and eLearning.

2 eLearning Supporting Knowledge Transfer for SMEs

SMEs are diverse and have specific organizational needs and characteristics. Their vision is bounded by the skills, horizons and experience of the founder, by the pressure of day-to-day management and tight resources. In regard to staff training and learning, most SME managers expect their staff to acquire new skills and knowledge as part of a collective responsibility for the company's profitability and growth (http://thecknownet.com).

Referring to suitable learning methods for their staff, in comparison to conventional training, eLearning methods with their flexibility of time and place have objectively many advantages for SMEs. Properly developed eLearning creates a growing repository of knowledge that will continuously deliver to employees just what they need to know at a determined time and in a way that can be individualized to be more efficient.

Studies [4] and the EU ARIEL project (Analysing and Reporting on the Implementation of Electronic Learning in Europe www.ariel-eu.net/), [6, 18], show that eLearning in SMEs often faces a series of problems. Factors which may cause these problems include knowledge gaps and training offered to staff in order to acquire the necessary competences which instead of being systematically identified, has been drawn mainly from practical experience and using informal methods.

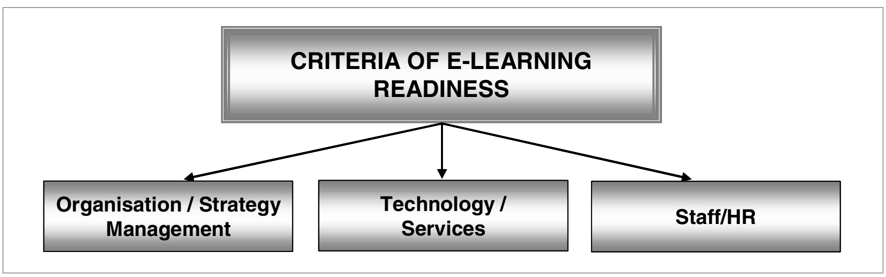
Also, many SMEs do not have the necessary infrastructure for knowledge management and learning. Some indicators can be found which show that nowadays, although SMEs are more active in eLearning due to technological innovations, specialised providers and programs like LERNET [8], this is not enough to improve their innovation abilities. The recommendations of LERNET are that both

SMES and eLearning providers should take into account the aspect of knowledge management in the process of eLearning.

The findings of ARIEL were elaborated further in the EU project SIMPEL (www.simpel-net.eu), a European project also financed under the European eLearning initiative [7]. In SIMPEL an "optimal model" for the introduction of eLearning in an SME has been developed and CoPs have been initiated.

The aspects we present below have been considered within SIMPEL. The first is an assessment of eLearning readiness. The Economist Intelligence Unit [12] cited by Psycharis [28] has published some models of eLearning readiness. The authors regard eLearning projects less on the basis of technical implementation processes but more on the necessary organisation development and organisational integration.

In our model a list of questions for the evaluation of eLearning readiness has been provided in a reference catalogue which takes into consid-eration the main criteria Organisation/Strategy/Management, Technology/Services, Staff/Human Resources (Figure 1). Experience shows that a suitable assessment of eLearning readiness in SMEs (having limited resources) can be realized in the form of a simple questionnaire survey for managers and individual employees to fill in. After data collection, the results should be evaluated by an eLearning consultant of the company and completed/detailed in direct discussion with the company staff and management. The next step is the building of an eLearning strategy to support knowledge transfer.



Source: IAT

Fig. 1 Criteria of eLearning readiness

<u>*Organisation/Strategy/Management*</u>

- Which are the strategic objectives and reasons for implementing/using eLearning? Are KM and innovations included?
- Is the adequate understanding that learning to support KM means much more than implementing an ICT tool or solution?
- Is there a well structured knowledge base of the enterprise that can be used by the staff when they would like to use it?
- Has the company a vision of how KM can support company business?

- Is there knowledge to be transferred and used between different units available in understandable formats?
- Are financial resources available for eLearning?
- Is the learning culture of the organisation supportive of sharing knowledge?
- Does the company management support eLearning?
- Are staff interactions favourable towards knowledge sharing?

Technology/Services

- Is the ICT equipment and workplace connections Internet compatible?
- When new ICT acquisitions are discussed, is the availability of technology suitable for knowledge sharing a main point?
- Does the existing ICT equipment support effective communication across boundary and even time zones?
- Are ICT and Web used for learning and communication by staff?
- Do virtual learning communities exist in the organisation?
- Is the content to be learned suitable for eLearning to support KM?
- Is there a strategy to protect key information and shared knowledge in the enterprise and/or is there a complete ICT security procedure for information?

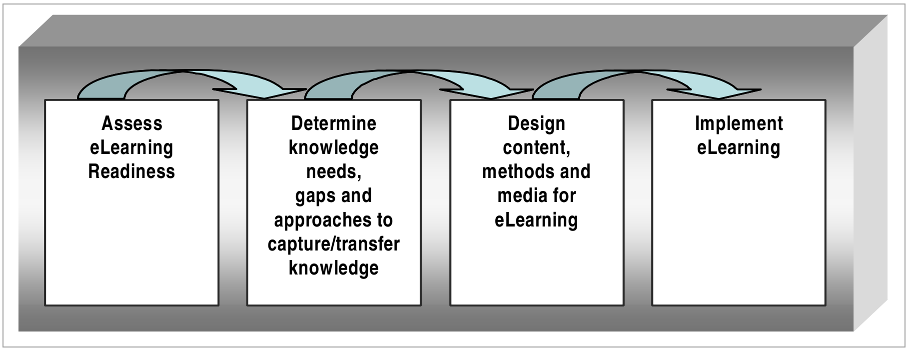
Staff/HR

- Do the staff understand the term KM and how to use existing knowledge for their business and work?
- What are the ICT skills of the target groups for eLearning?
- Are the staff motivated and ready to learn?
- Are trainers and tutors educated for eLearning?
- Which are the most used vocational training forms in the company?
- Do training strategies based on eLearning exist in the company?

Another approach presented in this paper in supporting the development of an eLearning strategy for KM, is to realize a knowledge audit [9] which refers to SME business goals or, in context with an innovation, which identifies gaps between existing knowledge and knowledge requirements.

The definition of knowledge audit is defined by National Electronic Library for Health [25]. The audit results including knowledge flows should be analyzed by looking at how knowledge moves around the company, which ICT support the flows, who the actors are who possess/need the knowledge for the innovation, how they share the knowledge they have and how knowledge should be transferred by eLearning.

One of the first steps after determination of the business/innovation knowledge gaps is to determine the nature of the gaps as a result of training deficiency or inefficient ICT tools for KM. Once the nature of the gap has been understood, an optimal approach to address the gap should be developed i.e. by using new interactive web-based tools and resources such as knowledge repositories or by providing additional opportunities for training by using eLearning.



Source: IAT

Fig. 2 eLearning value chain supporting KM in SMEs

Formal methods to capture knowledge through the company and to transfer it during the learning processes should be defined. It is known that much knowledge in organisations is likely to be informal, ad-hoc and undocumented. This type of knowledge is often distributed informally via staff interactions. An innovation-oriented SME should recognize the value of this knowledge and define approaches for its capturing.

Another aspect is the design of the appropriate eLearning content to be guided by the SME's knowledge requirements and innovation plans. Content can involve knowledge required by staff to perform their tasks and help to improve products and services offered to clients. Knowledge concerning new markets, customers and suppliers that needs to be transferred to the staff by eLearning can also be part of the content of eLearning.

It is important to keep SME staff's skills and knowledge up to date. Training seminars with this objective should use a combination of conventional methods and eLearning to address knowledge needs in the most suitable way, i.e. declarative knowledge by using Web sites or other references. Classrooms should be used more for exploring issues interactively, for simulations and for role play.

A wide range of media should be used to develop interactions with learning environments and to communicate messages.

Mentors should be well-prepared and equipped to train small groups of individuals on specific topics for their tasks. Such eLearning sessions can be accomplished at the workplace by synchronous cooperative learning sessions of small groups using Inter/Intranet communication. This form is also suitable for knowledge transfer within the company.

3 Communities of Practice

In APQC´s recent research [1] some of the most effective approaches for capturing, sharing and transferring knowledge are listed. One of them refers to CoPs. CoPs are groups of people working together at solving open-ended questions, learning in social and physical contexts of real-world problems and using collaboration and cognitive tools for KM and learning. Some main characteristics of CoPs are the following [31]:

- a shared domain of interest of its members, their commitment to this domain and a shared competence,
- common ideas, joint activities.
- common practice, members being practitioners with different expertise.

The concept of CoPs has been revisited by several academics; sharing and transferring knowledge and learning seem to be the most relevant aspects of the concept.

In CoPs, knowledge is created when people participate in solving a common problem and exchange the needed knowledge for the problem. Sharing knowledge makes more sense in the context of a CoP because its members have common interests in learning and exchanging experience in their specific area of activity and this favours reciprocal trust. Trust is a key facilitator necessary for the effective transfer of knowledge and is important for the creation of a common pool of knowledge that can also be used for a new/innovative product or service. Therefore, CoPs play a critical role in the promotion of learning and innovation in an organisation and can become a powerful tool in generating sustainable competitive advantages for SMEs. They are an alternative to building teams particularly in the context of an innovation. The tacit knowledge accumulated over years from experience can be processed to invent new products or services that add value to SMEs. Innovation depends also on how people apply knowledge to produce solutions for old and new problems.

Internet technologies [10, 20] extend the interactions within communities of practice beyond geographical limitations and make possible the building of virtual CoPs (VCoP). These communities free their members from constraints of time and space. In comparison to technical solutions for knowledge management, VCoPs can mark a change from “managing knowledge” to “enabling knowledge.”

Web 2.0 [22, 27] has a vast potential to create prospering environments for emerging CoPs. It can efficiently support activities within a community. It also supports the collaboration of SME staff through interactive web-based procedures as well as the concept of connectivism developed by Siemens [30] whereby information is constantly changing, the learning which takes place in distributed networks of people is based on diversity of opinion and where content and services are adaptable and responsive to the specific needs and goals of SMEs.

The use of eLearning 2.0 in CoPs also impacts on formal learning settings where it is particularly useful for pedagogical approaches such as collaborative learning and problem and enquiry based learning.

We have presented some benefits derived from transferring knowledge and from learning in CoPs by a sense of shared interests and an extending/deepening knowledge which derived from ongoing interaction.

Despite the great potential, there are also barriers and limitations particularly of current technologies in relation to virtual communities of practice. The lack of face-to-face contact within a CoP can often be an advantage, because it helps to suppress traditional group norm behaviour. On the other hand, it remains open if a community of practice where face-to-face contact is entirely excluded can be sustained over a long period. Face-to-face interaction and socialization processes consolidate the relations between members and group membership. Trust is important for a VCoP and this develops primarily through face-to-face interactions.

Another aspect is that because virtual community infrastructure can be set up across cultures via the Web, cultural and language differences can change interactions and hinder the flow of CoP activities. The use of technology to bridge geographical gaps can lead to a misinterpretation of messages; cues and feedback are often missing. Crossing virtual boundaries between institutions can involve legal issues wherein knowledge transfer like data protection, becomes intellectual property.

A further important barrier to VCoPs refers to selectivity in the choice of ICT to support the CoPs [21, 29]. VCoPs need to use Internet standard technologies such as bulletin boards and Web ones. Many authors [15, 19] underlay difficulties of members with the ICT access and ICT skills referring for example to the use of on-line forums and eLearning training.

One of the difficult parts is the development of a knowledge repository. One person moderates the building of the repository and members have the option to submit and categorize content in the repository.

In order to assure an optimal interaction between users and the ICT platforms supporting KM in VCoPs with SME participation, methodologies and processes should be used for the interfaces taking into consideration not only the functionality of the CoP but also the ICT competences and learning abilities of the learning staff who are members. Interfaces should have a basic real level of usability [23].

4 Example

We applied the above ideas within the activities of the EU project SIMPEL [7]. We developed strategies to enable SMEs to take full advantage of the eLearning in their training. We involved SMEs and eLearning experts in two communities of practice (one European and one German) [17] to share learning and knowledge and to develop continuous vocational education strategies based on Web 2.0 leading towards the creation of dynamic personalized learning environments. The European CoP is a weakly framed CoP, the German one is strongly framed.

In the European CoP an "innovative and optimal vocational training model" for SMEs based on eLearning was developed. Best practice models for capturing and sharing of knowledge and for using eLearning have been collected and guidelines for using them written. The models and guidelines were first discussed, evaluated and improved in seminars with SME representatives and then disseminated within workshops and seminars. Trainers, researchers, PhD students and some SME managers also from countries who were not project partners required SIMPLE models to use them or to learn.

Within the European CoP a continuous knowledge transfer was realized between two universities and one research centre which are members of the CoP and which have accumulated much practical experience over the years in the transfer of knowledge across public and private sector, and the SMEs using the CoP as permanent or temporary members. The transfer was also realized through on-line forums and cooperative, interactive eLearning 2.0 sequences and virtual sessions on the Moodle [11] platform which support the CoP. Wikis on different required subjects have been used for work at common resources.

This CoP attracted sectors engaged in support, training, design/develop-ment use, in consulting and in policy formulation concerning eLearning in SMEs in the European Union. However, the participation of SME was less. We evaluated internally and externally the CoP activities and products and established that many SMEs did not possess adequate ICT skills to participate in the CoP virtual activities and that the advantages of CoPs and eLearning are not well understood by managers. In order to train SMEs to make more use of the Web 2.0 for sharing and acquiring knowledge and for improving interactions with their customers, it is intended to increase the activities of this CoP with attractive eLearning based tutorials including Web usability guidelines for SMEs. Workshops are also planned to improve the innovation ability and KM acceptance within European SMEs particularly in the new member states (within the next few months in Romania).

Another planned activity is to develop procedures for sharing knowledge between CoP members and a CoP knowledge repository.

The German CoP which is in development, focuses particularly on analysis and testing how formal and informal learning can be used together efficiently in SMEs by working and acting in CoPs [14, 16]. The design and use of new knowledge-intensive, innovative and efficient working environments and the development of an innovative work culture in SMEs (which is missing in many German SMEs) are two future themes for this CoP.

5 Conclusions

Based on studies, on the experience of other experts, practitioners and academic colleagues and through our projects we advocate the utilisation of eLearning and services of Web 2.0 for improving not only competences of SME staff but also the processes of knowledge sharing and transfer within companies and across them. In order to be efficient, eLearning has to be embedded in intelligent and adequate "mixtures" of different learning methods and technologies and linked to KM processes. The subjects of knowledge sharing and transfer should receive more interest from SMEs because they need to survive and to be innovative.

Our experience with transfer of knowledge for innovation and the results of other studies and projects show that there are many aspects that make the process of knowledge sharing and transfer difficult. Many companies, particularly those from new member countries and their employees tend to be hostile to knowledge sharing and lack trust. The idea of tacit knowledge is not understood/recognized. Many internal conflicts exist. A large number of SMEs have had negative experiences with innovative products/processes and are reluctant to try again. Motivation issues as well as sharing mechanisms and user-friendly methods and tools to facilitate the transfer are missing.

The initiating of knowledge sharing and transfer processes for innovations and the development of CoPs is a complex process. The authors experienced themselves difficulties in this context but the achieved results to date motivate them to continue.

It is important to help SMEs to have an open and adaptable attitude to such tools and methods by initiating corresponding cooperative projects.

References

[1] American Productivity and Quality Center–APQC, Retaining Today's Knowledge for Tomorrow's Work Force (2008)

[2] Amin, A., Cohendet, P.: Geographies of Knowledge Formation in Firms. Industry and Innovation 12(4), 465–486 (2006)

[3] Argote, L., Ingram, P.: Knowledge transfer: A basis for competitive advantage in firms. Organizational Behavior and Human Decision Processes 82(1), 150–169 (2000)

[4] Attwell, G., Dirckinck-Holmfeld, D., Fabian, P., Kárpáti, A., Littig, P.: ELearning in Europe – Results and Recommendations. Thematic Monitoring under the LEONARDO DA VINCI Programme. Bonn, Germany. Report., Impuls 010 (2003)

[5] Averill, S., Hall, T.: An observatory of eLearning in Small Medium Enterprises (SMEs). In: Richards, G. (ed.) Proceedings of World Conference on ELearning in Corporate, Government, Healthcare and Higher EducationChesapeake, pp. 220–225. AACE, VA (2005)

[6] Beer, D., Busse, T., Hamburg, I., Mill, U., Paul, H. (eds.): eLearning in European SMEs: observations, analyses & forecasting, Münster, Waxmann (2006)

[7] Beer, D., Busse, T., Hamburg, I., Oehler, C. (eds.): Improving eLearning practices in SMEs. Brussels. In: Proceedings of the SIMPEL final conference, Universitas-Györ, April 14 (2008)

[8] BMWT, E-Learning in KMU – Markt, Trends, Empfehlungen. Ein Leitfaden für Hersteller, Anbieter, Nutzer und Einsteiger. Ergebnisse des BMWi-Technologieprogramms LERNET. Bundesministerium für Wirtschaft und Technologie, Hrsg., Berlin (November 2008)

[9] Fai, C.C., Chin, K.K., Fu, C.K., Bun, L.W.: Systematic Knowledge Auditing With Applications. Journal of Knowledge Management Practice (2005)

[10] Diemers, D.: Virtual Knowledge Communities. Erfolgreicher Umgang mit Wissen im digitalen Zeitalter. Dissertation der Universität, St. Gallen (2001)

[11] Dougiamas, M.: Moodle: Using Learning Communities to Create an Open Source Course Management System, Perth, Australia (2004)

[12] The Economist, e-learning readiness rankings, Economist Intelligence Unit (2003), http://www-304.ibm.com/jct03001cjct03001c/services/learning/solutions/pdfs/eiu_e-learning_readiness_rankings.pdf

[13] European Commission, Observatory of European SMEs (2003)

[14] Garrick, J.: Informal Learning in the Workplace: Unmasking Human Resource Development. Routledge, London (1998)

[15] Geibert, R.: Integrating Web-based instruction into a graduate nursing program taught via videoconferencing. Challenges and solutions. Computers in Nursing 18(1), 26–34 (2000)

[16] Hall, B.: Learning goes online: how companies can use networks to turn change into a competitive advantage (Cisco Systems: Packet Magazine) (2000)

[17] Hamburg, I., Engert, S., Petschenka, A., Marin, M.: Improving eLearning 2.0-based training strategies on SMEs through communities of practice. In: The International Association of Science and Technology for Development: The Seventh IASTED International Conference on Web-Based Education, Innsbruck, Austria, March 17-19, pp. 200–205 (2008)

[18] Hamburg, I., Lindecke, C., Terstriep, J.: Analysing interaction with computer of SME staff in eLearning processes. In: HCI International 2005: 11th International Conference on Human-Computer-Interaction, Las Vegas, Nevada. MIRA, July 22-27, p. 10 (2005)

[19] Hong, K.-S., Lai, K.-W., Holton, D.: Students' satisfaction and perceived learning within a web-based course. Educational Technology and Society 6(1), 116–124 (2003)

[20] Johnson, C.: A survey of current research on online communities of practice. Internet and Higher Education 4, 45–60 (2001)

[21] Kelly, P., Gale, K., Wheeler, S., Tucker, V.: Taking a stance: promoting deliberate action through online postgraduate professional development. Technology Pedagogy and Education 16(2), 153–176 (2007)

[22] Kerres, M.: Potenziale von Web 2.0 nutzen. In: Hohenstein, A., Wilbers, K. (Hrsg.) Handbuch eLearning, München (2006)

[23] Krogh, G., Ichijo, K., Nonaka, I.: Enabling Knowledge Creation. How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation. Oxford University Press, New York (2000)

[24] Krug, S.: Don't Make Me Think! A common sense approach to web usability. Indianapolis, New Riders (2000)

[25] National Electronic Library for Health (2005), http://www.nelh.nhs.uk/knowledge_management/km2/audit_toolkit.asp

[26] Nonaka, I., Konno, N.: The concept of 'ba': building a foundation for knowledge creation. California Management 40(3), 40–54 (1998)

[27] O'Reilly, T.: What is Web 2.0. Design patterns and Business models for the next generation of Software (2005), http://www.oreillynet.com/lp/a/6228

[28] Psycharis, S.: Presumptions and action affecting an e-learning adoption by the educational system. Implementation using virtual private networks, European Journal of Open and Distance Learning (2005)

[29] Schwen, T., Hara, N.: Community of practice: A metaphor for online design? The Information Society 19, 257–270 (2003)

[30] Siemens, G.: Connectivism: A learning theory for the digital age. International Journal of Instructional Technology and Distance Learning (2005)

[31] Wenger, E., McDermott, R., Sydner, W.: Cultivating communities of practice: a guide to managing knowledge. Harvard Business School Press, Boston (2002)

The Use of Open Source Software Licensing in Academia

Stephen J. Marshall

Research & Enterprise, University of Glasgow, Glasgow G12 8QQ, United Kingdom

Abstract. Open Source Software (OSS) is computer software in which the source code is freely available and included as part of the software distribution. This paper considers the use of OSS licensing for university-originated software. It examines the advantages of OSS and the issues surrounding it from both the developer and the end user perspective, and also discusses how OSS can be used as a mechanism for knowledge transfer in academia.

1 Introduction

Open Source Software (OSS) is computer software in which the source code (the list of instructions in human-readable form that are written by the programmer in order to create the program) is freely available and included as part of the software distribution. A typical OSS license permits others to view, use, modify and redistribute the source code. It may also include a *copyleft* clause, whereby all modifications and extensions to the original code must also be made available under the same terms.

The release of software under an OSS license is not the same as placing it in the public domain. OSS licenses uphold intellectual property rights (IPR) and can be an effective tool for maintaining strict control over how the software is used. Those that include a copyleft clause have been specifically designed to prevent software from becoming proprietary by ensuring that all derivative code remains freely available, irrespective of how little of the original code remains. Most also provide reasonable protection against liability and warranty claims.

The origins of OSS lie in the *hacker* culture of US computer science laboratories in the 1970s and the free exchange of software based on the UNIX operating system which took place during that period. This led to the formalisation of the OSS principles of openness and cooperation and the establishment of organisations to support and promote OSS, beginning with the Free Software Foundation in 1985.

Boosted by the emergence of the World Wide Web in the 1990s, OSS has grown to become one of the most influential and disruptive developments to hit the computer industry since the invention of the microprocessor. The movement that surrounds it has become a powerful voice in our increasingly IT dependent society, prompting the adoption of open licensing models for other forms of creative works and stimulating a wider debate on the copying of digital material.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 179–187.
springerlink.com

2 The Vision

Advocates of OSS harbour a utopian vision that harks back to a time before the software industry existed, where computers were such a rarity that manufacturers would willingly provide software with their machines at no extra cost and users freely swapped their latest programs with other users around the world. In order to understand why OSS supporters are so intent on turning the clock back, it is necessary to look more closely at what drives those behind it. The Open Source movement is surprisingly diverse in its motivations and beliefs but it is possible to divide it into two camps;

- Those who believe that software should be open in order to improve quality and interoperability. For these people, OSS is primarily a development methodology. This view is represented by the Open Source Initiative (OSI).
- Those who believe that software should be free, both in monetary terms and in terms of the freedom to do anything they like with it. For these people, OSS is an ideology. This view is represented by the Free Software Foundation (FSF).

The OSS development methodology is essentially a distributed peer review process, where the source code is opened up so that the wider developer community is able to contribute to its development and that "Given enough eyeballs, all bugs are shallow" [1]. This process is claimed to significantly improve the quality and reliability of software.

The principal goal of the ideology camp is freedom for computer users. This includes freedom to view, use, and modify software, and to redistribute copies with or without changes. It also extends to other types of creative works in digital form, in particular those that are protected by Digital Rights Management (DRM) technology, such as music and video files.

Both camps have tapped into a growing dissatisfaction with proprietary software, fuelled by a perception that proprietary code is of poor quality and the companies that produce it are greedy and self-serving. The continued market dominance and dubious public image of the Microsoft Corporation has undoubtedly contributed to this and it is interesting to note that Microsoft is often explicitly named by OSS devotees as the physical manifestation of all that is bad in the software industry.

2.1 Attraction for Developers

For software developers, OSS is a means of harnessing the resources of an expanded development team when creating new code. This is particularly attractive to small companies with limited resources and can lead to significant improvements in the speed of development. OSS projects are also a rich source of ready-made software routines that developers can build into their own projects and new ideas that they can learn from.

The continually expanding size and complexity of software has also increased pressure on developers to improve interoperability and maintain backward compatibility through many generations of the same product. OSS can help here too by making it easier for developers to see how other software works.

2.2 Attraction for End Users

The most obvious attraction of OSS for end users is that there are no license fees. However, OSS is also attractive to those organisations whose reliance on a particular software product may be critical to their business. Such organisations tend to have major concerns over the risk of inadequate or diminishing support for the product, either through product obsolescence or if the vendor goes out of business. They become locked into a seemingly endless cycle of product upgrades from which it can be almost impossible to break free. With OSS, users have the comfort of an extended community of developers whose independence makes them less vulnerable to the whims of the market.

In addition, because the source code for OSS is freely accessible, there is also the option of supporting the software in-house. This option also provides organisations with the flexibility to customise software to their own requirements or to port the code to new hardware if necessary.

3 The Reality

Much of the media attention given to OSS has focused on the end user perspective but it is when we examine it from a developer perspective that many of the issues surrounding OSS are revealed.

3.1 Commercialisation Issues

In theory, an OSS license does not prevent anyone from selling the software but in reality no one will buy it if the source code is freely available, unless the seller is also providing some kind of added value. Also, with OSS products there is no exclusivity, as the seller cannot prevent anyone else from selling the software too.

The standard business model for OSS is not to attempt to make money from the software itself but to sell support, documentation or consultancy services, thereby providing the added value. Perhaps the best known example of this is the US firm Red Hat which has created a highly profitable business out of Linux, an OSS operating system, by selling a subscription-based enterprise version complete with telephone support, network updates, glossy manual and installation software, all of which make it much easier to install and use than the freely downloadable versions. Red Hat and the other Linux vendors are successful because the market for Linux is huge but this business model is not viable for niche market software and an alternative model has yet to be found. Therefore, despite the growing popularity of OSS, investors remain reluctant to put money into an OSS business venture.

Furthermore, a recent article in BusinessWeek [2] has suggested that the continually improving quality of OSS products is working to reduce the need for support, thus reducing the potential for generating income from it.

3.2 Intellectual Property Rights

The concept of a community of individual developers working together on OSS projects is based on the assumption that each is free to contribute their Intellectual Property (IP) to the project. Unfortunately, this is seldom the case, as the majority of contributors are likely to be employees of one kind or another and in most industrialised nations IP generated by an employee through the course of his or her employment legally belongs to the employer. In the UK, this is embodied in the Patents Act 1977 and the Copyright, Designs and Patents Act 1988.

As a form of written work, source code is automatically protected by copyright. However, IPR is a complex subject which is open to legal interpretation and the use of the words "in the course of his or her employment" in the Acts has led some employees to argue that IP generated at home or without the use of their employer's resources should be exempt. We can see how this might be viewed by the courts by examining a 1989 case, *Missing Link Software v. Magee*, in which the question arose as to whether copyright in software written by an employee outside of work time and on his own equipment was made in the course of his employment and thus owned by his employer. The claimant company argued that since they had employed the defendant to write programs of the kind in dispute, similar programs, even if written in his spare time, were created in the course of his employment. The court held that although the employee had written the software in his own time and on his own equipment, nonetheless it was not unarguable that as it fell within the scope of the tasks he was employed to carry out, the computer programs were created within the course of his employment. Based on this precedent, his employer owns the copyright in the work created by him.

Therefore, when it comes to software professionals, the situation is quite clear. Any software that they write, irrespective of whether it is during or outside of normal working hours, legally belongs to their employer. In circumstances where an employee's duties do not specifically include software development, it may be possible for the employee to successfully argue that the IP that they have generated is entirely unconnected with their normal duties as an employee and therefore belongs to them. However, in order to avoid the possibility of a legal dispute, the employee should first obtain the written agreement of their employer that no attempt will be made to assert ownership rights over any software that they create.

OSS hosting web sites such as SourceForge.net do include copyright infringement warnings under their terms of use but a general lack of awareness of this issue within the OSS community and the absence of any formal due diligence or checking process when releasing source code under an OSS license suggests that a significant proportion of OSS projects may be tainted by IPR problems.

3.3 Professionalism

Having established that the majority of software professionals are unlikely to be free to contribute their IP to OSS projects, let us consider who is free to do so. Self-employed and contract software engineers are not usually bound by employer's IP rights but are unlikely to be strongly motivated to write OSS code unless they can earn a living from it, and the unpaid volunteer nature of OSS development tends to rule out this possibility. The Open Source movement has its roots in academia but academics employed by universities are also unlikely to own the rights to their IP, having been bound by the same laws that govern employees in industry. Students, however, are not normally university employees and consequently are likely to have more freedom to engage in OSS projects but their lack of practical software development experience will be a considerable drawback.

One category of potential contributor who is likely to be free to participate in OSS projects is the hobbyist or enthusiastic amateur. However, this gives rise to uncomfortable similarities with a situation that arose in the computer games industry in the early 1980s, where legions of *bedroom programmers* produced video console games of such poor quality that, despite selling in reasonable numbers, they nearly destroyed the industry. The computer games industry learned a valuable lesson from this experience and is now arguably the most highly trained and disciplined software development community in the world. This professionalism in software development is widely considered to be a major contributory factor to the explosive growth in the video games market over the last 10 years or so. It is in stark contrast to the Open Source movement, with its hacker ethic that eschews professionalism and actively encourages the participation of self-taught amateurs.

3.4 Conceptual Integrity

Like any creative process, good software needs a lead designer (or software architect in the current industry jargon) with a clear design concept which must be adhered to rigorously otherwise the software will lose structure and become more difficult to manage as it is developed in a piecemeal manner. Brooks calls this *conceptual integrity* [3].

History shows that the greatest advances in technology are usually made by focused, strong-willed individuals, often supported by a small team of dedicated engineers, not community-based projects. The OSS development methodology of distributed peer review can be a highly effective technique for improving code quality. However, peer review is, or should be, part of the conventional software engineering process and it is no substitute for a coherent architectural vision which the community-based model of software development does not foster.

3.5 Innovation

The absence of design leadership in the OSS development methodology, coupled with the temptation for OSS developers to create free versions of their favourite proprietary software, may also explain why there would appear to be a distinct lack of imagination in OSS projects. The Open Source movement has so far tended to create facsimiles of proprietary packages rather than the next *killer application*. Linux is an excellent case in point. Despite containing many powerful new tools and utilities, it is in essence a facsimile of UNIX, the proprietary operating system originally developed at Bell Telephone Laboratories in 1969. Ironically, the much reported robustness of Linux owes more to the good design of UNIX and its older relative, Multics, than it does the OSS development methodology.

3.6 Security

Because the source code for OSS programs is freely available, it can be scrutinised for security weaknesses much more easily than proprietary software and any that are found may be more readily exploited. Of course, if these weaknesses are caused through bugs in the software, the community of OSS developers should find and correct them quickly but this will be much more difficult if the weaknesses are inherent in the design of the software.

3.7 Industry Concerns

Many of the proponents of OSS may have failed to consider the longer term effect of OSS on our fragile software ecosystem. A continued shift towards OSS solutions at the expense of proprietary ones could result in many of the companies that develop proprietary software going out of business. Despite this alarming prospect, a number of leading information technology firms are actively supporting the Open Source movement through organisations such as The Linux Foundation in a blatant attempt to topple Microsoft from its lofty position of dominance over the industry. Unfortunately, the first companies affected are likely to be the small but highly innovative firms that are the lifeblood of the software industry, not the giant corporations that we all love to hate.

4 Use in Academia

Despite the issues highlighted above, OSS does have a legitimate place in academia. Releasing university-originated software under an OSS license can stimulate new research collaborations, free up source code for teaching purposes and allow it to be included in research publications and textbooks. An OSS release may protect the long-term future of critical research software by making it more widely available, thus increasing the number of users and developers. OSS is also an efficient mechanism for knowledge transfer as it requires less administrative effort and is a faster, more direct route to market than licensing software on commercial terms.

As academic research continues to push the boundaries of technology, there is an argument that all university-originated software should be released as OSS in order to maximise its benefit to industry. However, software licensing can be a significant source of revenue for universities (Stanford University has earned $336 million from licensing search engine technology to Google) and most will wish to continue to be able to generate income from it whenever the opportunity arises while also allowing their academics some freedom to engage in OSS development projects if they wish to do so.

4.1 Institutional Drivers

In 2004, the Office of the e-Envoy (OeE) and the Department of Trade and Industry (DTI) recommended the adoption of OSS as the default exploitation route for UK government-funded R&D software outputs [4]. Therefore, if no commercial or community-shared exploitation route is specified in the final project report, an OSS default will apply for all software developed under any UK government-funded research project. Unfortunately, this policy could lead to situations where such software remains undeclared until after the end of the project, either deliberately or inadvertently, whereupon the default exploitation route automatically comes into effect. In order to minimise the risk of research software with significant commercial potential slipping through the net, it is important for universities to have a clear institutional policy on OSS.

From a strategic perspective, OSS can have powerful advantages under certain circumstances. For example, if the software is *enabling* technology and provides a platform for other software or hardware but is of little commercial value on its own, an OSS release could establish a user base, thereby providing a ready market for the proprietary software or hardware that sits on top. This strategy has been applied successfully with the University of Glasgow's Terrier software, a state-of-the-art information retrieval platform that enables the rapid development of web, intranet and desktop search engines. A basic version of Terrier was released under an OSS license but certain key parts of the technology have been withheld and remain proprietary. The OSS version has now been downloaded many thousands of times since it first became available at the end of 2004, attracting considerable publicity and stimulating several research collaborations. It has also been possible to generate income from Terrier through consultancy services for customisation work and by licensing the proprietary code on commercial terms.

4.2 Academic Motivation

With its origins in academia, OSS is an attractive proposition to many academics whose research involves software development. When working with these academics, it is important for knowledge transfer managers to understand their motivation. Those who are ideologically motivated are likely to be less inclined to consider alternative licensing options and may insist that all the software that they create should be released as OSS. Also, as the IP policy in many universities includes a waiver of rights to ownership of any copyright in *Scholarly Materials* (textbooks, conference papers, presentations, etc.), it is often assumed that this also includes source code, particularly if the institution concerned grants authors a non-exclusive, non-transferable, royalty free license to use their software for academic publication. In such cases, it may be necessary to remind academics that they have no authority to issue licenses on behalf of the institution and that they should work with their Technology Transfer Office to choose the most appropriate license to suit the circumstances.

4.3 Choice of License

UK government policy states that only OSS licenses which are compliant with the Open Source Definition can be used. The OSI is the organisation tasked with managing and promoting the Open Source Definition on behalf of the OSS community. It operates a license approval programme whereby new licenses may be submitted for approval by the OSI Board. Obtaining OSI approval for a university license would be proof of compliance with the Open Source Definition but considerable time and effort would be required to draft the new license. A simpler option would be to use an existing license that has already obtained OSI approval.

The OSI web site (www.opensource.org) currently lists 66 OSI-approved OSS licenses. These can be grouped into two basic license types that reflect the beliefs of the two main camps within the Open Source movement;

- Licenses that permit others to view, use, modify and redistribute the source code but place few additional restrictions on developers other than that they retain the original copyright notice. The best known example of this type is the Berkeley Software Development (BSD) license.
- Licenses that include a copyleft clause, thereby constraining developers from making the code proprietary or combining it with other code that is licensed under different terms. The best known example of this type is the GNU General Public License (GPL).

There is also a third type of OSS license which is essentially a compromise between both in order to permit OSS and proprietary code to be mixed under certain conditions. The best known example of this type is the Mozilla Public License.

In cases where an assessment of the software has concluded that it has no commercial value but the originators wish to stimulate new research collaborations by encouraging other groups to use it, any of the three basic types of OSS license would be suitable. However, a BSD-type license could prevent access to source code produced through further development by other groups and a GPL-type license might discourage other developers through fear that it would dictate how they license their own code. Therefore, it may be more appropriate in such cases to use the Mozilla Public License, a less extreme form of the GPL license but one that retains the copyleft provisions necessary to allow the university researchers to benefit from further development of the software by other groups.

In cases where the software has commercial potential but there are no prospective licensees on the horizon and it would be difficult to justify withholding an OSS release, the Mozilla Public License would also be an appropriate choice. Like the BSD-type license, it does not restrict the use of the software in the development of a proprietary product, however, unlike the BSD-type license it retains the copyleft provisions that would allow the originators to benefit from further development of the software by other research groups.

A third scenario is where there is a specific requirement to prevent competitors from creating proprietary versions of university-originated software released as OSS. In this case, the GPL would be the logical choice. However, this license should be used with extreme caution, as it would effectively prevent any commercialisation whatsoever of the software or its derivatives under any circumstances.

Further advice on OSS licensing for university-originated software can be obtained from OSS Watch (www.oss-watch.ac.uk), an advisory service funded by the Joint Information Systems Committee (JISC) to help higher and further education institutions in the UK who are using or developing OSS.

5 Conclusion

Releasing university-originated software under an OSS license can be an effective mechanism for knowledge transfer when used appropriately. However, there are pitfalls and its use should be carefully managed. A key requirement is an institutional policy that is sympathetic to the needs of academics who wish to engage in OSS development activities but does not restrict the organisation's ability to generate licensing income in cases where there is significant commercial potential.

References

1. Raymond, E.S.: The Cathedral and the Bazaar. O'Reilly & Associates, Sebastopol (1999)
2. Cohen, S.: Open Source: The Model is Broken, BusinessWeek Special Report (December 2008)
3. Brooks, F.P.: The Mythical Man-Month and Other Essays on Software Engineering. Addison Wesley, Reading (1974)
4. Open Source Software: Use Within UK Government, Cabinet Office e-Government Unit (October 2004)

Using Emotional Intelligence and NLP Training to Promote and Sustain Relationships within KTPs

Ruth Slater, Ailsa Brotherton, Christina Lyons, and Karen Whittaker

University of Central Lancashire

Context

The School of Nursing and Caring Sciences at the University of Central Lancashire (UCLan) currently has 3 KTPs at various stages – one is completing year 2 of a 3 year project, another is just starting and one has experienced a delayed start because of initial problems with recruitment of an Associate. Participation in health KTPs is a new endeavour for UCLan because it only became possible to develop projects when eligibility criteria changed 3 years ago. It is also new for our partners.

Our partnerships are with local Primary Care Trusts (PCTs) and so the nature of the KTPs is different from those with traditional businesses or commercial companies. Primary Care Trusts are not profit making organisations; they commission and deliver patient care. For this reason, defining the "product' is not easy. In our projects, the 'products' are mechanisms to change behaviour through commissioning contracts. In addition, the business goal is to generate savings rather than profits. These savings can be articulated in a number of ways, such as actual money saved or budgets spent more effectively.

A specific interactive research model is emerging from our experiences. This involves actively engaging with stakeholders throughout the research process, from conceptualising the focus of the research to dissemination. It also takes account of aspects of knowledge brokerage[1]. Knowledge brokering brings people together, building relationships and sharing ideas and evidence that help healthcare stakeholders do their jobs better. Essentially, it is the human connection that makes knowledge transfer - the movement of knowledge from one place or group of people to another. Most knowledge brokerage models help draw researchers and decision-makers out of their silos helping them to see beyond their immediate boundaries so they can collaborate and communicate to arrive at evidence-based decisions. Brokering is the active, relationship-building aspect of knowledge transfer, a third-party role dedicated to linking researchers and research users so information, innovation and support can flow freely between them[2]. However, our

[1] Source: http://www.longwoods.com/product.php?productid=16807&cat=331&page=1
[2] Source: http://www.fcrss.ca/brokering/pdf/Montreal_Report_e.pdf

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 189–196.
springerlink.com

interactive model differs in that the researchers themselves, in addition to knowledge brokering; also engage in activities to bring about change rather than just acting as an independent third-party.

Anecdotal evidence from previous KTPs in other disciplines indicates that where projects fail, it is usually because relationships have broken down or do not develop appropriately. Our experience to date has been that a heavy investment in partner relationships is required for KTPs to be successful. This became apparent during the development of projects at the bid stage and has become increasingly important in sustaining the projects.

By focusing on partner relationships, it was possible to identify areas where skills development might be useful. It was agreed that a supportive training programme to enable partners to develop their relationship skills might help to sustain the partnerships.

2 Why Training?

We understood that in theory and in an ideal world, communication between all the parties involved in the partnership should be healthy, open and positive – all moving in the same direction towards a shared goal. Yet, where KTPs fail, it is often because there is a breakdown in the 'relationship' between the parties.

The breakdown of the relationship gets in the way of achieving the outcomes and work cannot proceed.

It was agreed that there could be great benefit in providing some 'communication' training at the initial stages of the partnership – highlighting the importance of self awareness, self management and relationship management during the communication process. By getting off to a good start, it was anticipated that this would help sustain the partnerships throughout the projects.

3 Why Creative NLP?

The purpose of the training was to help facilitate the KTP's achievement of objectives through heightened Emotional Intelligence; exploring communication and understanding how you think to achieve the results you want. This focuses on increased self awareness and self management coupled with increased social awareness and relationship management. Neural Linguistic Programming (NLP) focuses on your thought processes and how these affect physiology, emotions and behaviour (the neuro part), whilst the linguistic aspect explores the use of language to conceptualise and communicate experiences to others. The programming part supports the individual to understand their personal strategies and internal processes that influence learning, decision making and problem solving. By utilising a bespoke training approach, the aim of the training was to use NLP approaches to deliver the best possible outcomes for both the KTP projects and the partnerships.

The Creative NLP programme aims were tailored to give people the opportunity to find out about themselves along side others through experience, reflection and theory. This was to enable participants to play an active part in building on existing relationships (established in bid writing) and to create an even more motivated, dynamic and successful partnership.

A fundamental principle of the NLP training was that you firstly coach yourself to reach your full potential. The course was designed to enable individuals to:

- Become aware of the importance of knowing themselves and how to achieve their maximum potential.
- Develop a greater understanding of the value of excellent communication in all walks of life.
- Greatly enhance their ability to observe and listen to others; to listen to understand, rather than to reply.
- Develop greater flexibility and choice of their behaviour and language.

This provides them with a greater opportunity to work well with, and understand, the other members of their team:

- Manage change in an ever changing world.
- Gain greater self confidence and self esteem.
- Build more fruitful business relationships with a wider variety of people.
- Run more effective meetings including those involving conflict.
- Have a greater success rate in both planning and achieving defined objectives.
- Develop a greater awareness of how people are motivated thus enhancing performance.
- Improve their ability to coach and appraise people.
- Explore and achieve an appropriate work / life balance.
- Understand the importance of receiving and giving feedback.
- Know more of what you want and how to move forward.
- Have greater understanding about the important relationship between thinking, feeling and behaviour.
- Know more about what limits you place on yourself by thinking in the way that you think.
- Start to remove fears, rigidities and defences leading to greater self esteem.

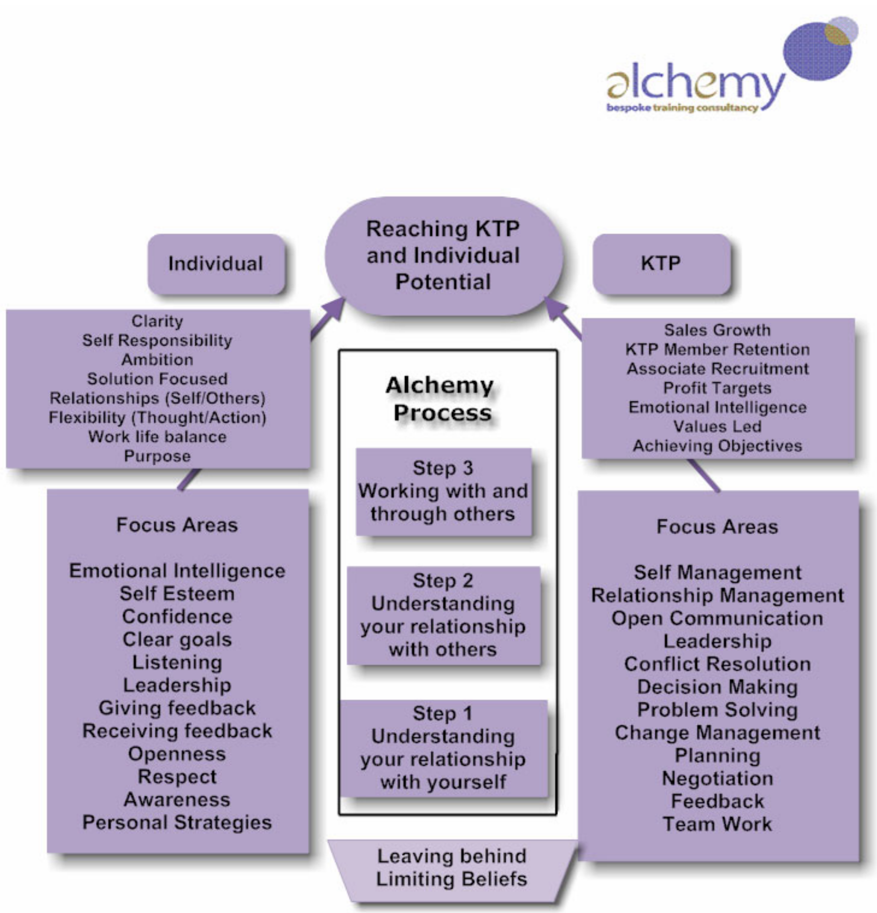
The anticipated benefits of the training programme were:

- KTP more likely to be a success.
- We recruit the right candidate.
- More compatible partnerships.
- Best practices shared.
- Productive partnerships.
- Additional personal and professional development.
- Enhancement of commitment.
- Motivation for KTP
- Establish ground rules enabling the group to be more focused and bond quicker.

- Great way of getting to know one another.
- Helps to spot the 'politics' early on and deal with them.
- A more united KTP will help the associate to get on board quicker.
- Less fire fighting.
- Less procrastination.

4 Our Training Model

Several training models were considered before the bespoke training provided by Alchemy was selected. This model of training was particularly relevant for our training needs as it incorporated the key features we were looking for; relationships, developing the individual and focusing on the KTP project for the benefit of the organisations involved in delivery of KTPs,

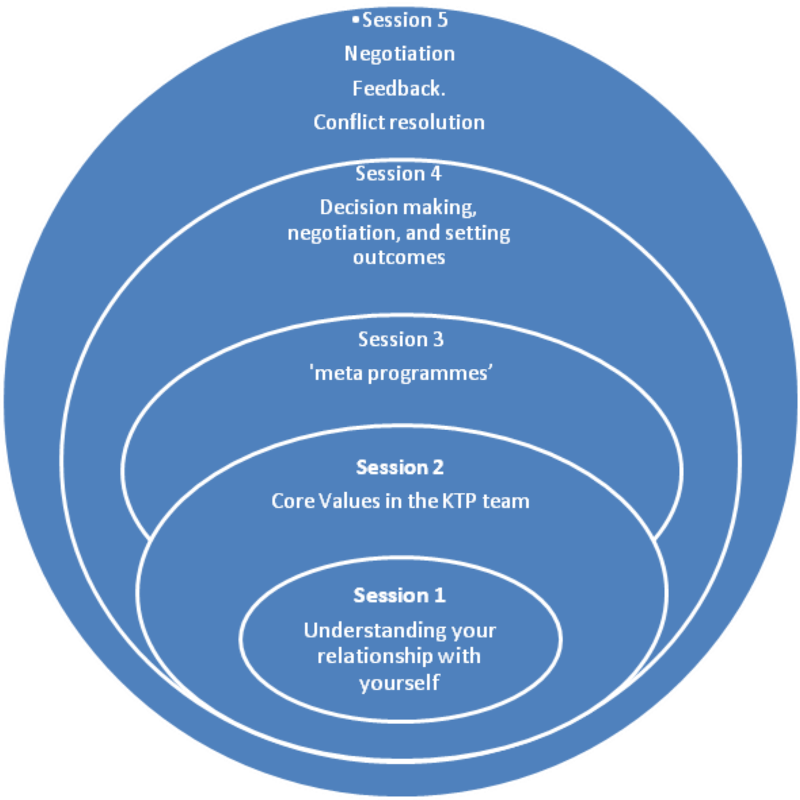


Reproduced with permission of Alchemy

5 The Training Model Developed

Initially there was a lot of uncertainty around what the group wanted and therefore the type of course to deliver. Overall it was agreed that the focus would be improving emotional intelligence and communication and how to improve these within the KTP teams so that they progress effectively. The training began with a focus on self and moved out through the small KTP team, the wider KTP team and ultimately the organisations involved in the partnership.

This allowed for recognition and understanding of the different cultures within the organisations and the demands on team members which led to a shared understanding of individual and organisational values and goals.



6 Residential and Session 1

The dinner and informal social evening with overnight stay was well received and enabled participants to socialise outside of their formal work environments. This helped both NHS partners and academics to be seen outside their formal work roles. It is possible that this helped challenge stereotypical views and enabled participants to be seen as individuals.

The following morning the group felt fragmented and diverse. Participants were joining and leaving at different times, whilst others were dealing with balancing the day alongside other issues. This raised the issues of commitment and prioritising time. This led to discussions about the sometimes unreasonable pressures people were working under, particularly NHS colleagues. There was some uncertainty about people's roles in the KTP and the relevance of this course and the content in terms of the KTP and the rest of their work life.

This produced a group of people some of whom were not sure whether to belong (inclusion issue). The overriding memory of the day was people 'toing and froing' – a sense of there not being enough time for this course – intertwined with some positive feedback and support.

7 Session 2

In response to feedback from the residential, session 2 focused on the process of the KTP as a means of uniting the group and getting a 'buy in' from individuals. In order to get a 'working group' the inclusion issue had to be resolved.

By working with individual values participants were able to explore what underpins who we are and how we work. From this we were able to compare and contrast values held within each KTP team in order to begin to build cohesive, values based partnerships. This led on to an exploration of each team's KTP working values. These values then became the foundation to the group – a reference point for decision making, conflict, leadership and vision. The participants that attended this session have remained the core group throughout the remaining sessions. Commitment was established.

8 Session 3

Ground rules were negotiated in terms of timings and topics of discussions and were agreed at the beginning of this session. This clearly helped with focus and bringing the group back to the agenda and also 'jelled' the group a little bit more.

The content of the session was based around 'meta programmes' – intrinsic values – how we each experience the world. The session was to aid the process of interviewing prospective associates for two of the KTPs. Interview processes usually concentrate on the knowledge and skills of the candidate – the Meta programmes help to identify people's attitudes, beliefs and values and their strategies (habits) – all of which can affect, sometimes adversely, knowledge and skills. This proved to be extremely useful for all members of the group. It enabled participants to become more aware of their own Meta programmes and provided greater insight into their own practices.

9 Session 4

Decision making, negotiation, and setting outcomes were the focus of this session. Workable models in each of these three areas were explored so that participants had something to take away and work with when needed.

With commitment and ground rules solidly established, by this session participants had achieved a great balance between completing the content and building rapport amongst one another.

10 Session 5

The focus of this session was to reflect on what the participants had learned and achieved. It became apparent that the roles of each member of the KTP team needs to be clear in order for individuals to feel more able to commit to the partnership and the training. The commitment (inclusion issues) should be established before embarking on this programme but the training helped to "cement" commitment.

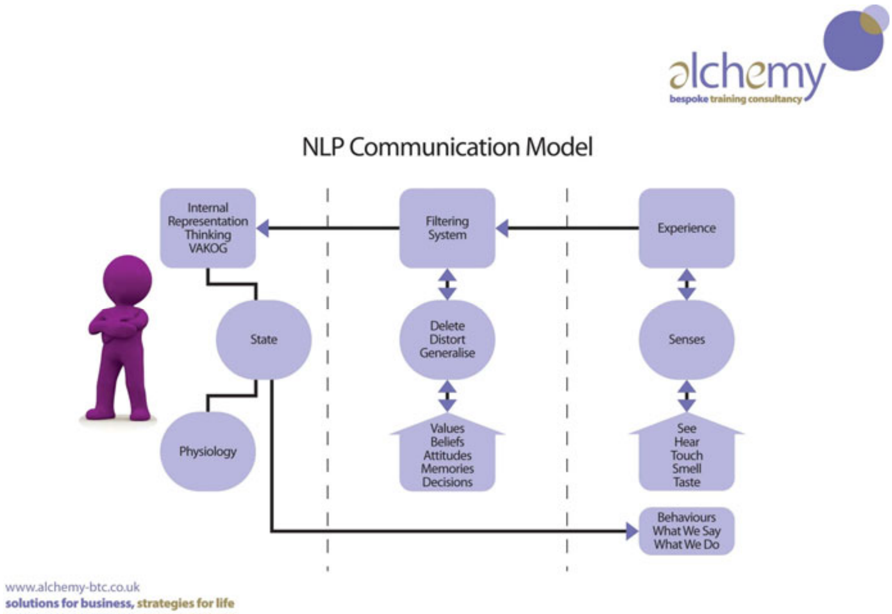
A number of key points arose:

- Managing the KTP through values.
- Understanding one another's Meta programmes.
- Decision making.
- Negotiation.
- Feedback.
- Conflict resolution.

Running along side all of these areas it is important to recognise continuous reference and awareness of individuals' communication styles and how to enhance communication with others.

A more cohesive, supportive group with a willingness to develop themselves and their KTPs has emerged from this process. There seems to be more willingness to address issues now that the group is moving towards greater openness and increased honesty with one another. This type of work requires a willingness to engage with the process and recognise that all participants are all on a development path. Each individual comes to this path at different stages and therefore although all participants are exposed to the same knowledge and skills, how we use them may differ. This may be contingent upon individual propensities but also how open and honest we are with ourselves.

One of the significant outcomes at this stage of the evaluation is the improved communication. Using a new model of communication shared within the training has provided the teams with a shared language, focusing on listening to understand rather than listening to respond. Team members now fully understand the importance of checking out understanding and communicating this in a way that can be understood.



Reproduced with permission of Alchemy

11 Conclusion

Knowledge Transfer is not something new; everybody engages in Knowledge Transfer in one way or another. As such the need to support, manage and organise the process in a more effective and beneficial way was one of the key drivers behind the training.

KTPs are challenging and involve a team of diverse people who have individual wants but share a common goal. However, problems do arise as people do not always express what they truly feel, giving mixed messages, resulting in confusion.

The training was aimed at improving communication, building rapport and uniting the KTP teams. Individuals learnt new ways to communicate, how to respond and how to feel. Feedback so far has been positive. However, at this stage, we don't know how successful the training will prove to be in the longer term but we are very pleased with initial results.

So far the process has helped the teams develop their relationships and contributed to recruitment and selection of two KTP Associates. We plan to evaluate each KTP in six-months time and then again at the end of each Partnership.

Innovative Knowledge Transfer Mechanisms and the Potential Role for Theatric Methods in the Propagation of Good Data Handling Practice*

Fintan Clear

Brunel Business School, Brunel University, Kingston Lane, Uxbridge, Middlesex UB8 3PH
e-mail: fintan.clear@brunel.ac.uk

Abstract. This is a position paper that argues for the use of 'theatric methods' as an effective means of disseminating what to some might be regarded as complex and 'ostensibly dull' information, and in this case 'good data handling practice'. Protection of data in an electronically-mediated economy is critical both for a firm's trading integrity and for its competitive advantage. However standard training on data security is thought to be wanting given the complexity of the subject matter and the manner in which it is traditionally delivered. Additionally any system protecting data security should be tempered with the observation that its strength is 'only as good as its weakest link'. Thus this paper seeks to proffer an alternative approach for the propagation of good data handling practices, one that exploits theatric methods in order to make critical learning memorable. Though the methods described here are designed to be deployed as a means of raising awareness of security issues, they could be applied equally as well with other objectives in mind where the imaginations of groups of individuals need to be harnessed such as 'effective electronic collaboration across supply chains' or 'effective customer care in an electronic realm'.

1 Introduction

Hildreth and Kimble (2004) draw attention to the dynamic nature of the world of today: "The current environment for organizations is one that is characterised by uncertainty and continuous change. This rapid and dynamic pace of change is forcing organizations that were accustomed to structure and routine to become ones that must improvise solutions quickly and correct" (p. ix). Thus if firms are to have competitive advantage in a highly competitive global economy, they need

* A paper for submission to the First International Conference on 'Innovation through Knowledge Transfer. Research with Impact', Hampton Court Palace, London, 2 December 2009.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 197–208.
springerlink.com

to be innovative in their use of electronically-mediated communications (or 'e-business'). By definition, the role that electronic communications play in business and its dependency on data security must be of critical interest to firms. This prompts Teece *et al.* (1997) to argue that as business environments increase in dynamism and complexity, firms lose the ability to incrementally adapt to change and therefore fail to maintain competitive advantage. Spinellis *et al.* (1999) argue that advanced technology has in many cases outpaced the development of 'control practice and employee knowledge'. Thus it seems clear that the greater use of electronically-enabled communications may pose complex challenges for a firm's data security. Additionally this complexity is further compounded by the observation that a security system can only be as strong as its weakest link. So no matter how comprehensive a security system may be in technical terms, for example, the fact that such a system may be compromised by inadvertent or malicious human revelation demonstrates a vulnerability of electronically-mediated working.

Whatever the source of risk, Reuvid (2004) argues that management controls and processes overseeing security are critical factors for firm survival. Thus Higgins (1999) observes, "a policy is the start of security management" (p. 217) and that "Effective security management … is based on the systematic concept, dissemination and operation of an information security policy". In the absence of such a policy, businesses may be seen as vulnerable, whether as the result of accident or malevolence. So a firm having a policy suggests that at least some appraisal has been made of potential security threats, however imperfect.

In a WestFocus-sponsored study (SMEs) entitled "ICT Adoption and Use by SMEs" (reported on by Clear, 2007 and Harindranath et al., 2008), the overwhelming majority of the 378 'Small and Medium-sized Enterprises' (SMEs) were shown to avail themselves of Internet-based ICT and hence electronically-mediated trading. Such developments have taken place in a relatively short space of time given that the Internet has gone from an essentially unknown business tool to one with pervasive use in less than 15 years (given Year Zero as 1995 when the Netscape IPO occurred). Thus it might come as no surprise that Clear (2007) finds that much of this innovation is undertaken against a backdrop of questionable security policy and training practice, offering potential threats for the integrity of networked trading. When examining the use of a security policy in regard to distributed working, 28% of the micro firm sample had no such policy while in the case of small firms, 18% of firms had no such policy. However good or bad an indicator of security posture that the use of a data security policy is, Schneier (2000; 2003) and Walden (2005) argue that security issues are not properly understood or given adequate attention in many organisations whatever their size. Press reports noting the loss, for example, of 25 million data records by the UK government's 'Revenue and Customs' service when two disks were sent through the postal system unencrypted appear to support such a contention. Thus it is asserted that provision by government of highly 'user-friendly' web resources such as 'Get Safe Online' (http://getsafeonline.org) is not enough to effect the fundamental shift in human behavior as regards data handling required of the new electronically-mediated world.

Fillis et al. (2004) appear highly critical of the academic literature by warning of "the continued belief by many researchers in the sole value of formalised, structured, prescriptive ways of conceptualising business behavior despite the realities of non-linear, sometimes chaotic behavior" (p.350). If a firm's security posture is only as good as its weakest link, then propagation of security awareness to all members of a firm using 'formalised, structured, prescriptive' means of training delivery and standard linear progression may be unlikely to deliver optimal levels of such knowledge. In any event most data security awareness training is constructed by information security specialists who do not necessarily have a strong educational background (Van Niekerk and Von Solms, 2003), and this has been shown to lead to ineffective security training (Siponen, 2000). Fiedler (2003) in any event argues that the nature of knowledge work creates particular demands which in many cases cannot be met by traditional instructional design anymore. If security awareness is indeed critical, then there is a case for the use alternative means of delivery such as by use of performing arts, especially drama. So in place of standard training delivery, the object would be to mount a form of 'show' or learning event underpinned by solid pedagogical theory in which certain key learning points may be given a theatric treatment that attempts to draw out and make more immediately apparent the application of certain knowledge. If learners can be engaged and residual trust built upon, then it is intended that internal knowledge transfer will be optimised, allowing creativity, innovation and enterprise in the development of a surer understanding of data security and perhaps new working practices.

The 'situated-action' view of knowledge underpins the 'interactionist, constructivist view of knowledge' (Nooteboom, 2000: 113) and is the general perspective informing the use of 'theatric methods' evinced here. Thus the object in using theatric methods would be to break away from traditional didactic means of instruction whereby 'knowing' and 'doing' are separated thus treating knowledge as an 'integral, self-sufficient substance, theoretically independent of the situations in which it is learned and used' (Brown *et al.*, 1989: 32). Brown *et al.* see activity and situations as being integral to learning. Thus aspects related to 'data security' would be imparted through a series of theatric events in which learners may participate in learning via an experiential route rather than through an abstract manner. Brown and Duguid (2002) argue that a focus on process has a tendency to draw attention away from people and to disembody and to de-contextualise knowledge. There may be an abundance of information on data security, for example, that is codified in books, journals and on websites, but Brown and Duguid ask how individuals might be in a position to assimilate, understand and make sense of this information without context.

Venter and Eloff (2003) note a taxonomy of information security technologies and their list of 'proactive' technologies includes cryptography, digital signatures, virtual private networks, anti-virus scanners and security protocols and their list of 'reactive' technologies includes firewalls, access controls, passwords, biometrics, and intrusion detection systems. Brown *et al.* (1989) argue that knowledge is like language in that its constituent parts index the world and so are 'inextricably a product of the activity and situations in which they are produced' (Brown *et al.*, 1989: 33). This holds for 'apparently well-defined, abstract technical concepts……part of their meaning is always inherited from the context of use' (Brown *et al.*, 1989: 33). Thus knowledge and skills underpinning data security may be imparted to some extent by a 'situated-action' approach to learning and while it might not be expected that an employee has an exhaustive knowledge of each of these technologies, the manner in which they are discussed using theatric methods would impart some knowledge in terms of the notion of good data handling practice. So while a 'situated-action' approach might not be a perfect means of delivering 'chapter and verse' on such technologies, it might at least offer an effective means of rapid learning for example on inappropriate uses of such technologies. This would constitute a form of 'experiential learning' (Kolb, 1984).

Figure 1 shows Kolb's 4-stage model of experiential learning. The theory of experiential learning sees it as a "holistic integrative perspective on learning that combines experience, perception, cognition, and behaviour" (Kolb, 1984). The object of a 'learning event' using 'theatric methods' then would be to try to re-create some analogue of the working environment as a means of 'situating' critical learning points. While working life moves at its own speed, additionally the object would be to reproduce learning in a relatively brief timescale that might ordinarily take place over an extended period of time in the actual workplace. Pre-scripted and improvised vignettes may therefore represent the 'concrete experience' leading to 'observations and reflections' and hence the 'formation of abstract concepts and generalizations'. Following the vignettes some form of game might be mounted which then allowed 'testing implications of concepts in new situations'.

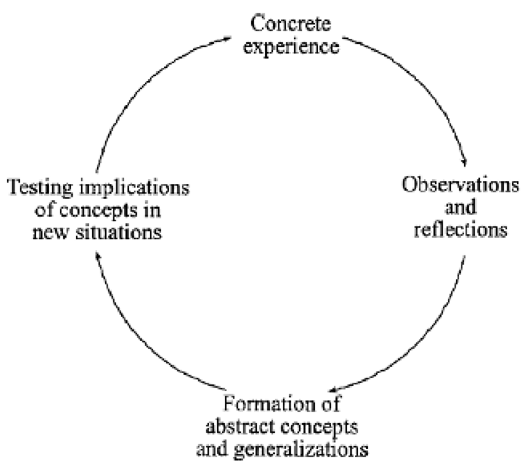


Fig. 1 Kolb's 4-stage model of experiential learning (as shown in Miettinen, 2000)

Tidd *et al.* (1997) note two forms of knowledge, one that "can be codified, i.e. described in terms of formulae, blueprints, and rules…(and one) that cannot easily be codified, often termed, 'tacit', (which) is by contrast, much more difficult to acquire, since it can only be transferred effectively by experience and face-to-face interactions". Nonaka and Takeuchi (1995) maintain that successful knowledge transfer requires that such internalised tacit knowledge held by some individuals needs to be shared with others. Thus 'performers' could help to draw out tacit knowledge held by expert employees (as long as individual experts are happy to reveal it) and to facilitate its codification so that previously 'hidden' knowledge can be revealed to all. While the actors may have a 'jobbing' knowledge about data security, the likelihood is that those who know most about a firm's data security needs are people in the firm itself.

The subject area of data security has certain attributes that could be explored fruitfully, this author contends, using theatric methods. It is a highly complex field, with relatively limited levels of understanding and knowledge across the population at large (following Schneier, 2000 & 2003 and Walden, 2005). The subject is multi-faceted and causality between technology and human agency can be highly complex. In-depth knowledge and skills concerning 'data security' is likely in many firms to be restricted to a limited number of employees, typically within the 'IT staff'. However while 'the few' may be in a position to supply all the technical defences for 'the many', it is not possible for 'the few' to supply the necessary human defences for 'the many', at least in so straightforward a fashion. So while 'the few' can take up responsibilities for the 'technical' domain, all of 'the many' need to take responsibility for combating the 'human threats' such as social engineering attacks. For example, any member of staff may receive a 'phishing' attack via email and all therefore would need to be aware of the possibility of such a threat and know how to handle it. In these terms, arguably 'safe data handling practice' is as much an attitude of mind as a set of protocols, and some fundamental change of thinking for many employees may be required for a firm to work safely in these terms. These attributes mean that a standard lecture/workshop mode for dissemination of critical material on data security may be unlikely to succeed well in regard to attitudinal change, for example, or to conjure up self-sustaining dialogue necessarily. Lack of base knowledge and understanding for some may mean that the following of a narrative may be difficult in any event. Needless to say the subject of data security is a sensitive one and discretion on the part of facilitators is required. Some firms in fact might be inhibited from seeking such support for learning on this subject given such sensitivities.

2 Arts-Based Learning and Knowledge Transfer

Ideas about the use of theatric methods as a method for education and instruction go back at least to Aristotle. More recently the use of fictional devices in the delivery of 'science' instruction was manifest for example in the popular BBC Radio 4 soap opera 'The Archers' which was originally conceived as a means of disseminating new agricultural methods to the UK farming community at a time of food shortages just after WWII: the scientific message was framed within a fictional account of the lives of everyday folk in a rural community.

Winston (1999) argues "Drama brings a singular coherence to past, present and future action; we see motives, deeds and their consequences with a simultaneity and clarity that is denied us in lived experience. This simplification of life need not render it simplistic; rather … it can sharpen the audience's appreciation of the complexity of individual moral lives (Winston, 1999: 464). So a scan of the Web will reveal theatre groups in different parts of the world bringing issues 'to life' as Winston argues for the purposes of awareness raising of bullying, racism, sexism, domestic violence, eating disorders, HIV/AIDS, sexual harassment, substance abuse and so on. As an example, a work entitled 'Ball' by Brian Lobel (undated) uses his knowledge of artistry and health to perform a one-man, multi-media play (held now on YouTube) to present a frank discussion of his personal experience of testicular cancer. One commentator watching the performance in a Qualitative Methods conference "was amazed by the way in which his particular story could convey and transfer knowledge and certainly emotion in such a direct way; it certainly stays in your memory and (is an) experience much better than simply reading an account of his challenges" (noted in Graham, 2009). In this vein Monks *et al.* (2001) cite initiatives such as the Globe Theatre in London which runs leadership workshops based on Shakespeare's "Henry V" to explore ethical issues in the workplace, and "A Winter's Tale" which is used as a prop to explore the process of managing change.

While there appears to a lot of practice exploiting theatric methods as a means of 'knowledge transfer', published academic literature on the subject is relatively limited to date though arguably it is growing and gathering pace. However it is soon evident that no discussion of theatric methods and alternative means of learning is possible without pointing to the work of Augusto Boal. In a 40-year career in non-traditional theatre Boal began by trying to encourage oppressed peoples to develop their own voice by which to defend their rights. Over time his 'Forum Theatre' (Boal, 1979) method evolved away from the traditional performance approach such that suggestions for narratives and cases to be explored in theatric form came directly from the audience or 'spect-actors' who may themselves take a direct part in the event by acting out a role in some improvised performance. A number of the sources explored below make use of 'Forum Theatre' for knowledge transfer purposes, whether as a means of gathering data or of presenting research findings. The participatory aspect of the method means that narrative is not restricted to a 'top down' authorial approach. With the use of 'bottom up' sourcing of ideas, richer and more authentic narrative can be developed on an improvisational basis with the effect of generating a strong form of ownership over the material by those taking part. This leads to consolidation of learning and the heightening of group identity, an aspect that could be exploited to great effect when considering the matter of data security and the fact that 'you are only as strong as your weakest link'.

One area that appears especially strong in regard to the use of theatric methods as a means of knowledge transfer is health. For example in 2008 the Journal of Health Psychology devotes a special edition to use of the arts in health work.

Murray and Gray (2008) in their introduction to the special edition entitled, 'Health Psychology and the Arts, A conversation' argue for the exploration of 'new methods of working' and the use of 'new theoretical ideas from other disciplines' and point to articles showing how different forms of art might be exploited to further health projects in different contexts whether 'clinical, community (or) educational'. For example, Thomas and Mulvey (2008) explore the use of creative writing, visual arts, poetry, film, and theatre as a means of promoting student understanding of the values, goals, and practices of community-based work in order to enable 'meaningful student roles in community-based partnerships'. A number of the authors rely on the work of Boal. Thus Sullivan *et al*. (2008) show how 'Forum Theatre' can be used to promote the involvement of citizens, scientists and health professionals in 'deconstructing toxic exposures, risk factors, and cumulative stressors that impact the well-being of communities'.

Rossiter *et al*. (2008) use focus group data from traumatic brain injury (TBI) survivors, family members and professional caregivers to create a series of dramatic representations by which to inform health professionals of the 'lived realities' of such patients. The authors note that while the 'artists' found trouble in interpreting the 'data' as presented, the health professionals found the work to be 'emotionally engaging' and helped them to reflect upon the rehabilitation process for TBI patients. Nevertheless Rossiter at al. (2008) provide caveats and note that in order to translate knowledge between science and art, the writer of the drama (termed the 'dramaturg') 'must be proficient in the languages of both disciplines', in this case the science of TBI and the art of dramatic representation. They provide a taxonomy of four theatre genres and make an analysis of the benefits and disadvantages for 'non-theatrical performances', 'ethnodramas', 'theatrical research-based performances' and 'fictional theatrical performances'. Apart from the fact that the first of these descriptions appears to be a misnomer given that even a reading aloud of a document is arguably theatric, Rossiter *et al*. nevertheless show how 'Forum Theatre' can be exploited to give interactivity to such knowledge representations and hence greater authenticity and critical edge.

Kontos and Poland (2009) outline a 'Critical Realism and the Arts Research Utilization Model' (CRARUM) that combines critical realism and arts-based methodologies as a means of highlighting what new clinical practices would mean in different healthcare settings. They argue that knowledge transfer initiatives that neglect the contextual settings for change can undermine successful uptake of new practice and also fail to predict how such new practice might work best in a given context. Additionally they note another limitation of such 'knowledge translation' initiatives as being a neglect of methods that would engage potential adopters of the innovation in a critical reflection about practice, the relevance and meaning of innovation in the context of that practice, and the identification of strategies for bringing about meaningful change in practice settings. Though the authors fail to provide enough detail on how their methods would work in practice, they argue nevertheless that their CRARUM model has the potential to strengthen the science of implementation research by addressing the complexities of practice settings and engaging potential adopters in critical reflection of their own existing practices as well as proposed practices and strategies for sustaining change.

Knowles and Cole (2008) see the performing arts as offering a means of unlocking knowledge flows between different communities and academia and as a means of garnering rich data sets in research domains: “Arts-informed research is part of a broader commitment to shift the dominant paradigmatic view that keeps the academy and community separated: to acknowledge the multiple dimensions that constitute and form the human condition—physical, emotional, spiritual, social, cultural—and the myriad ways of engaging in the world—oral, literal, visual, embodied. That is, to connect the work of the academy with the life and lives of communities through research that is accessible, evocative, embodied, empathic, and provocative” (Knowles and Cole, 2008: 60). In this vein the ‘Arts-Based Educational Research Special Interest Group’ of the American Educational Research Association (AERA) was formed in 1997 as a focus for research approaches using ‘arts-informed’ ethnographic methods such as painting, dance, creative non-fiction, poetry and theatre as means of representing working life and associated knowledge. This in turn led to the University of Toronto formalising its own arts-informed social science research in 2000 with the establishment of CAIR (Centre for Arts-Informed Research). Its web site notes its ‘mission’ as being “to articulate, explore, and support alternative forms of qualitative research and representation which infuse elements, processes, and forms of the arts into scholarly work”.

While much appears to have been written on the use of theatric methods in health and allied disciplines, as a means of knowledge transfer in business *per se*, the literature is less forthright. Beckwith (2003) is one who argues for the use of the performing arts (especially drama and music) as a means of influencing workplace attitudes and employee motivation, as well as being a method of dramatically representing complex business issues and being a catalyst for business creativity. She has since gone on to co-found a training company called ‘Smith Beckwith’ which advances these methods of human resource development in the corporate sphere. Newell *et al.* (2006) examine the use of theatrical techniques as a means of stimulating discussion between prospective users of a system and the system designers. They found that such techniques were particularly useful with what they describe as ‘extreme users’, i.e. older and perhaps disabled users who had little experience in the use of computer applications and who may also have had little confidence in being able to express their usability desires using more conventional means. Quoting Grudin (2006) they note that, “Data from psychological studies and artistic experience indicate that we naturally and generatively create and engage with detailed representations of people….Most of us do not naturally reason about extensive statistical summaries, but we do reason effortlessly about people, real or fictional”. The use of these techniques therefore offers greater accessability to what might ostensibly be dry material. Additionally Newell *et al.* (2006) note the value of using *in vivo* performance and its ability to engage an audience when citing Sato and Salvador (1999) who argue that “Live performers cast a spell over the room; there was a heightened awareness and tension, and live actors can produce engaging and interactive experience” (Sato and Salvador, 1999). This ‘animation’ of material is an aspect noted by other writers such as Boud and Miller (1996), Brookfield

(1986) and Heron (1989) who all argue for the use of 'facilitators' or 'animateurs' (ie those who animate learning) to maximise impact in experiential learning contexts.

Not all research is equivocal however on the use of theatric methods. Monks *et al*. (2001) used such methods to promote learning in three different Higher Education classes. The results were mixed but appear to show a gender dimension in which females were more likely to 'buy in' to the methods as a means of knowledge transfer than males. Disappointingly the authors are not entirely clear on the nature of the material presented. Nevertheless, though these findings prompt more questions than answers, it is hoped that there is enough evidence in the limited but growing literature to support the proposition of using theatric methods in the dissemination and propagation of good data handling practices.

Although these ideas and the theatric methods used to put them into practice are still in development, it is envisaged that such an approach would demonstrate the following attributes:

a) Use of 'performers' would give a sense of spectacle and significance to learning. ('Performers' include actors, musicians, teachers, and members of an audience).
b) Use of pre-scripted and improvised vignettes deployed by the actors that play out typical and extraordinary business scenarios as a basis for comment and discussion.
c) Use of games to explore content, perhaps using a competitive element and/or humour, as a means of surfacing issues and to consolidate knowledge.
d) Use of music both as a means of generating metaphor and to offer interlude and structure within a learning event.
e) Some level of exercisable choice for learners as to the subject matter to be explored.
f) The potential for contingent action by performers when significant holes in knowledge are discovered such that supporting material might be presented and/or pointed to in order to ensure some level of awareness in that area (incidentally this does not necessarily have to contradict the principle noted in e) of 'some level of exercisable choice').
g) Interactive in thrust, intending to offer dialogue rather than monologue.
h) Seeking to promote interest, curiosity and ongoing dialogue (i.e. beyond the learning event) on subject matter that might be regarded by some as 'ostensibly dull'.
i) Interdisciplinary in approach.
j) Offering potential value in change management scenarios where fundamental shifts in thinking and behavior are required.

In order to maximise the engagement of learners, one essential aspect of the methods would be the use of trained actors. What can actors do that ordinary mortals cannot? A trained actor should have an ability to 'shape shift' convincingly to allow different characters to be represented. Additionally a trained actor will be aware of a host of techniques for vivifying words and actions that in all likelihood the untrained will not. This does not mean to say that someone with charisma who is ‘untrained’ in this manner cannot hold the attention of a group for sustained periods. Rather the proposition here is that use of trained performers can guarantee some level of ‘drive’, ‘morale’, ‘energy’ or ‘charisma’ within a learning group for a set period.

The object is to maximise engagement of the learning participants so that they share and create new knowledge with an assured ease. At base this requires the group to enjoy the experience at a personal level at least, and this may be the product of different theatric styles as required. So whereas a traditional ‘classroom’ approach sees the teacher and the taught as clearly delimited with a (mostly) one-way flow of ‘knowledge’ from ‘expert’ to the ‘inexpert’ (in these terms), actors exploiting scripted and improvised theatric methods could encourage a form of experiential learning environment in which expertise is evinced by ‘performers’ and ‘participants’ alike. With participants now assured of the locus of internal expertise in addition to the identity of further sources of knowledge, such an event might be concluded with a form of ‘game show’ that sought to ‘test’ knowledge acquisition by individuals or teams so that learning might be consolidated. Arguably therefore the theatric methods outlined in this account hold some promise for the effective dissemination and propagation of good data handling practice. Though the underlying pedagogy of this innovative mechanism of knowledge transfer still requires development, proof of its impact requires empirical examination.

3 Conclusion

This is a position paper that argues for the use of ‘theatric methods’ as an effective means of disseminating what to some might be regarded as complex and ‘ostensibly dull’ information, and in this case ‘good data handling practice’. Protection of data in an electronically-mediated economy is critical both for a firm’s trading integrity and for its competitive advantage. However standard training on data security is thought to be wanting given the complexity of the subject matter and the manner in which it is traditionally delivered. Additionally any system protecting data security should be tempered with the observation that its strength is ‘only as good as its weakest link’. Thus this paper seeks to proffer an alternative approach for the propagation of good data handling practices, one that exploits theatric methods in order to make critical learning memorable. Though the methods described here are designed to be deployed as a means of raising awareness of security issues, they could be applied equally as well with other objectives in mind where the imaginations of groups of individuals need to be harnessed such as ‘effective electronic collaboration across supply chains’ or ‘effective customer care in an electronic realm’.

References

Beckwith, A.: Improving business performance – the potential of arts in training. Industrial and Commercial Training 35(5), 207–209 (2003)

Boal, A.: Theatre of the Oppressed, Theatre Communications Group (Translated by McBride, C, 1985) (1979)

Boud, D., Miller, N. (eds.): Working with Experience: Animating Learning. Routledge, London (1996)

Brookfield, S.: Understanding and Facilitating Adult Learning. Open University, Milton Keynes (1986)

Brown, J., Collins, A., Duguid, P.: Situated Cognition and the Culture of Learning. Educational Researcher 18(1), 32–42 (1989)

Brown, J., Duguid, P.: The Social Life of Information. Harvard Business School Press (2002)

Clear, F.: SMEs, electronically-mediated working and data security: cause for concern? International Journal of Business Science and Applied Management 2(2) (2007)

Graham, P.: Knowledge Transfer Methodology (2009), `http://www.methodspace.com/groups/group/show?id=2289984%3AGroup%3A4862` (accessed August 21, 2009)

Harindranath, G., Dyerson, R., Barnes, D.: ICT Adoption and Use in UK SMEs: a Failure of Initiatives? The Electronic Journal Information Systems Evaluation 11(2), 91–96 (2008)

Heron, J.: The Facilitator's Handbook. Kogan Page (1989)

Higgins, H.: Corporate system security: towards an integrated management approach. Information Management & Computer Security 7(5), 217–222 (1999)

Hildreth, P., Kimble, C. (eds.): Knowledge Networks: Innovation through Communities of Practice. Idea Group Publishing, USA (2004)

Knowles, J., Cole, A. (eds.): Handbook of the arts in qualitative research: Perspectives, methodologies, examples, and issues. Sage Publications, Thousand Oaks (2008)

Kolb, D.: Experiential learning: experience as the source of learning and development. Prentice Hall, Englewood Cliffs (1984)

Kontos, P., Poland, B.: Mapping new theoretical and methodological terrain for knowledge translation: contributions from critical realism and the arts. Implementation Science 4(1) (2009)

Lobel, B.: Ball (undated), `http://www.youtube.com/watch?v=2aia9H6867Q` (accessed August 21, 2009)

Monks, K., Barker, P., Ni Mhanachain, A.: Drama as an opportunity for learning and development. Journal of Management Development 20(5), 414–423 (2001)

Murray, M., Gray, R.: Health Psychology and the Arts, A conversation. Journal of Health Psychology 13(2), 147–153 (2008)

Nardi, B.: Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition. MIT Press, Cambridge (1996)

Newell, A., Carmichael, A., Morgan, M., Dickinson, A.: The use of theatre in requirements gathering and usability studies. Interacting with Computers 18(5) (2006)

Nooteboom, B.: Learning and Innovation in Organizations and Economies. Oxford University Press, Oxford (2000)

Nonaka, I., Takeuchi, H.: The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press, Oxford (1995)

Reuvid, J.: The secure online business handbook: E-commerce, IT functionality and business continuity, 2nd edn. Kogan Page, London (2004)

Rossiter, K., Kontos, P., Colantonio, A., Gilbert, J., Gray, J., Keightley, M.: Staging Data: Theatre as a Tool for Analysis and Knowledge Transfer in Health Research. Social Science and Medicine 66(1), 30–46 (2008)

Schneier, B.: Secrets and Lies: Digital Security in a Networked World. John Wiley, New York (2000)

Schneier, B.: Beyond Fear: Thinking Sensibly about Security in an Uncertain World. Springer, Heidelberg (2003)

Spinellis, D., Kokolakis, S., Gritzalis, S.: Security requirements, risks and recommendations for small enterprise and home-office environments. Information Management and Computer Security 7(3), 121–128 (1999)

Siponen, M.: A Conceptual Foundation for Organisational Information SecurityAwareness. Information Management & Computer Security 8(1), 31–41 (2000)

Sullivan, J., Petronella, S., Brooks, E., Murillo, M., Primeau, L., Ward, J.: Theatre of the Oppressed and Environmental Justice Communities: A Transformational Therapy for the Body Politic. Journal of Health Psychology 13, 166–179 (2008)

Teece, D., Pisano, G., Shuen, A.: Dynamic Capabilities and Strategic Fit. Strategic Management Journal 18, 510–533 (1997)

Tidd, J., Bessant, J., Pavitt, K.: Managing Innovation: Integrating Technological, Market and Organisational Change. Wiley, Chichester (1997)

Thomas, E., Mulvey, A.: Using the Arts in Teaching and Learning. Building Student Capacity for Community-based Work in Health Psychology. Journal of HealthPsychology 13(2), 239–250 (2008)

Van Niekerk, J., von Solms, R.: Establishing an Information Security Culture in Organisations: an Outcomes-based Education Approach. In: Proceedings of ISSA 2003: 3rd Annual IS South Africa Conference, Johannesburg, South Africa, July 9-11 (2003)

Walden, I.: Crime and Security in Cyberspace. Cambridge Review of International Affairs 18(1), 51–68 (2005)

Winston, J.: Theorising drama as moral education. Journal of Moral Education 28(4), 459–471 (1999)

Occurrence and Influencing Variables of Knowledge Barriers in Knowledge-Intense Domains

Carolin A. Fiechter, Christoph Kuderna, and Eva-Maria Kern

Universität der Bundeswehr München
Werner-Heisenberg-Weg 39
D-85577 Neubiberg
e-mail: carolin.fiechter@unibw.de, eva-maria.kern@unibw.de

Abstract. Especially innovation processes require in-depth knowledge and thus depend on the quality of knowledge transfer within these processes. Accomplishing a case study, the influencing variables and the occurrence of knowledge barriers in innovation projects of the German Armed Forces are analyzed with a special focus on cross-organisational and cross-functional knowledge transfer. Based on a conceptual study on the incidence of knowledge barriers in project work, data on knowledge barriers in seven departments of the German Armed Forces are gathered to empirically test the impact of theoretically derived influencing variables. The objective of the case study is a) to give statements about occurrence and characteristics of knowledge barriers in innovative and knowledge-intense domains and b) to deduce possible approaches to prevent knowledge barriers by identifying relevant influencing variables.

Keywords: Knowledge Transfer, knowledge-intense domains, knowledge barriers, influencing variables.

1 Introduction

Innovation projects can not only be found in industry, but also in government organisations. Especially in the Armed Forces, innovation on products, processes and concepts is crucial. Around these innovations, multiple knowledge-intense processes occur. Those may be subject to factors constricting or even inhibiting knowledge transfer, so called information pathologies or knowledge barriers (Wilensky 1967, Schüppel 1996, Lehner 2008). According to Kern et al. (2008), those barriers may occur in the sphere of the organisation (e.g. strong hierarchies limiting processes of knowledge transfer), of technology (e.g. limited access to databases) or humans (e.g. mistrust).

While much research has been conducted in identifying knowledge barriers and predicting their effects on knowledge transfer (e.g. Bullinger et al. 1997,

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 209–217.
springerlink.com

Davenport and Prusak 1998), little attention has been given to examine potential influencing variables that may enable or enforce the occurrence of knowledge barriers themselves.

Thus, this paper addresses some potentially relevant influencing variables and examines their values and the occurrence of knowledge barriers within seven departments deployed with knowledge-intense tasks linked to different types of innovation projects. It aims to give evidence for the impact of potentially influencing variables by analysing correlations between those variables and identified knowledge barriers.

2 Method

2.1 Units of Analysis

In this explorative multi-case study, seven departments of the German Armed Forces are examined. These departments are located across Germany and were chosen because of the knowledge intensity of their daily work and their direct work on or strong link to any kind of innovation projects within the Armed Forces. For reasons of data protection, the departments have been made anonymous and labelled “A” to “G”.

The German Armed Forces seem very suitable as unit of analysis, as main organisational variables are identical to all departments, such as organisational culture, hierarchical structure and functional specialisation. This reduces the number of variables with possibly different values and thus increases the significance of the results of this study.

2.2 Study Design

The study was conducted in two parts as it is shown in figure 1: On the one side, variables potentially influencing knowledge transfer and thus knowledge barriers were identified and operationalised and departments suitable for the study were determined so that the relevant data could be gathered. On the other side, knowledge barriers in these departments were identified by using a validated questionnaire (Hopf et al. 2005) which was adapted to the German Armed Forces in the course of a preceding study (Kern et al. 2008). By collecting data from the members of the departments on 108 items, values for 15 knowledge barriers could be determined per department and were translated into ranks. A complete list of knowledge barriers and their ranks will be given in the chapter “results”. The deviations between the departments in the occurrence of knowledge barriers will be checked in order to ensure the reliability of the following analyses.

Possible influencing variables were identified from literature (e.g. Werner 2004) and checked for potential impact on the analysed departments as well as for the criteria of not being already identically for all departments due to the overall organisational context. Thus, the externally determined variables (meaning they

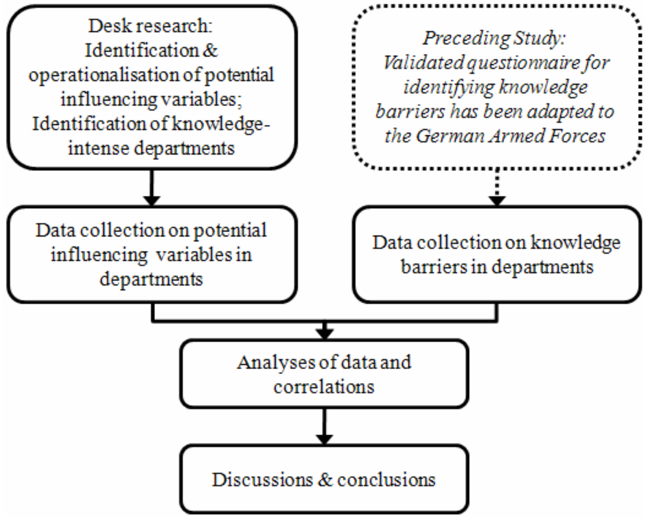


Fig. 1 Study Design

could not be influenced by the departments) selected were: Size of the departments, the heterogeneity of the department personnel and the physical proximity of the working spaces. Additionally, data was collected on the internally set variables "culture of team meetings" and "preoccupation with knowledge management" whose both form is decided on by the departments.

The variables were operationalised as follows: The size of the department was defined as the number of its members at the time of the survey. As increasing size is expected to enhance the occurrence of knowledge barriers (Castiglioni 1995, Senge 1998), departments were ranked from smallest to largest. The heterogeneity was measured by two items: First, the variation of the backgrounds of department members was measured by calculating the variance of the ratios of civil employees and of the military personnel's affiliation to one of the three military branches. Second, the relative distribution of the ranks (officers, sergeants and enlisted soldiers) is calculated and the heterogeneity in ranks is constituted by the total of the distances between those ranks. Both items are equally weighted to determine the value of the variable and thus the corresponding rank[1], with a high degree of heterogeneity being expected to enhance knowledge generation and transfer (Schröder 2003, Harmaakorpi and Mutanen 2008) and thus given a high rank.

[1] The value for the variation in backgrounds (vb) can range between 0 (maximum of heterogeneity) and 0.25 (maximum of homogeneity). The value for the rank distance (vr) can range between 0 (maximum of homogeneity) and 0.5 (maximum of heterogeneity). To compute a total value for heterogeneity (vh), vr has been inverted and both item values have been standardized to a range between 0 and 1. Thus, the degree of heterogeneity can be calculated as follows: vh = (4vb+2*(0.5-vh))/2.

The physical proximity of the working space was also evaluated by two items: The first one is the average ratio of personnel per office, with a higher ratio indicating a higher proximity. The second item is the spatial distribution of the office space, with a proximity value of 1 means being on the same floor, a value of 2 being on different floors in the same part of a building, a value of 3 being located in different parts of a building and value 4 being separated by special restrictions, e.g. by security zones. The total rank in physical proximity was constituted as the sum of the values of both items. As physical proximity is claimed to simplify communication and thus knowledge transfer (Werner 2004, Schröder 2003), high values in this variable are assigned low ranks.

Culture of team meetings was operationalised as regular meetings on all hierarchical levels being assigned to value 1 (and thus the highest rank), regular meetings on certain levels only to value 2, and a value of 3 for no regular meetings.

The last variable, the department's preoccupation with knowledge management, was also categorized into three levels, with the first one being "awareness for knowledge management and conduction of corresponding activities" (value: 1), the second one being "only partial preoccupation or preoccupation without conduction of relevant activities" (value: 2) and the third one being "no preoccupation so far" (value: 3).

An overview of the chosen influencing variables, the sources of their specifications and the relations between the values of the variables and the ranks assigned is provided in table 1.

Table 1 Examined Variables

Variable Name	Source	High value indicating...
Size	Externally set	Low rank
Heterogeneity	Externally set	High rank
Physical proximity	Externally set	Low rank
Culture of team meetings	Internally set	Low rank
Preoccupation with knowledge management	Internally set	Low rank

The correlations of the potential influencing variables and the knowledge barriers identified by the separate questionnaire will be calculated using Spearman's rank correlation coefficient Rho as a consequence of the small size of the sample and the fact that the values are not expected to be normally distributed.

3 Data and Empirical Results

3.1 Occurrence of Knowledge Barriers

Significant values could be measured for all 15 knowledge barriers tested. The mean coefficient of variation amounts to 8%, with a mean spreading of the single values of 21%. Table 2 provides an overview of the tested barriers and the ranks of the departments (labeled A to G) concerning those barriers, with rank 1 being the least affected by the respective barrier. For reasons of data protection, the corresponding values will not be specified.

Table 2 Ranks of knowledge barriers by department

	Department	A	B	C	D	E	F	G
# 1	Insufficient transactive knowledge	7	6	1	3	5	4	2
# 2	Loss of information	5	2	6	3	1	7	4
# 3	Insufficient internal acquisition of knowledge	6	3	1	2	7	5	4
# 4	Insufficient external acquisition of knowledge	7	5	6	2	3	1	4
# 5	Insufficient concern for knowledge management	5	7	4	2	6	1	3
# 6	Insufficient information storage	6	4	3	5	2	7	1
# 7	Being professionally blinkered / leaking awareness	7	5	1	6	4	2	3
# 8	Inadequate representation and misunderstandings	5	7	1	4	6	3	2
# 9	Mistrust and micropolitics	7	6	1	5	3	4	2
# 10	Inappropriate processes of handing over	6	5	7	3	4	1	2
# 11	Insufficient flow of information	7	4	5	3	6	1	2
# 12	Inadequate climate of communication	7	5	3	4	2	6	1
# 13	Insufficient culture of learning	6	7	1	2	5	4	3
# 14	Organisational culture of the department	7	5	2	6	4	1	3
# 15	Adverse management conduct	7	3	6	4	5	1	2
	Occurence of knowledge barriers: average rank	6,3	4,9	3,2	3,6	4,2	3,2	2,5
	Occurence of knowledge barriers: total rank	7	6	2,5	4	5	2,5	1

The strong deviations of the total average ranks of the barriers as well as significant spreading of the values of these barriers indicate a distinct diversity concerning the impact of knowledge barriers between the different departments. Thus, the data can be considered suitable for further analysis.

3.2 Values of Influencing Variables

In table 3, values for the influencing variables as described above are shown and the ranks determined, with rank 1 assigned to the variable value being expected to have the most favorable effect on knowledge transfer. The calculation of the variables values was carried out as defined in the chapter “study design”.

Also for the externally set variables, strong deviations between the values for the different departments can be observed. For the objectives of this exploratory multi-case study, these deviations can be considered distinct enough for the variables to be subject of further analyses.

Table 3 Values and ranks of influencing variables

Department	A	B	C	D	E	F	G
Value: Size (number of personnel)	100	29	29	216	26	45	95
Rank: Size	6	2,5	2,5	7	1	4	5
Value: Heterogeneity	0,31	0,32	0,70	0,68	0,28	0,63	0,62
Rank: Heterogeneity	2	3	7	6	1	5	4
Value: Physical proximity	5	2,5	5	7	4	5	5
Rank: Physical proximity	4,5	1	4,5	7	2	4,5	4,5
Value: Culture of team meetings	1	1	2	1	2	1	2
Rank: Culture of team meetings	2,5	2,5	6	2,5	6	2,5	6
Value: Preoccupation with KM	2	1	2	2	3	1	1
Rank: Preoccupation with KM	5	2	5	5	7	2	2

For the internally set variables, only minor deviations were detected. Though this reduces the liability of statistical analysis, these variables will be examined further with the results being critically discussed afterwards.

3.3 Analysis of Correlations

Using the Spearman's Rho algorithm, positive rank correlations on a 0.05 level of significance were identified for the variable "heterogeneity of the department personnel" and the barriers #01, #03 and #13 as well as for the variable "preoccupation with knowledge management" and the barrier #15. Negative correlations within the 0.05 level of significance were revealed for the variable "culture of team meetings" and barriers #06, #09 and #12 as well as for the variable "physical proximity of the working spaces" and barrier #05.

Medium correlations (Rho > 0.5) were found additionally for "size" and barriers #05 (negatively correlated) and #07; for "preoccupation with knowledge management" and barrier #11 and for "heterogeneity of the department personnel" and the barriers #02, #05 and #08.

Table 4 provides the correlations detected with their Rho and the corresponding level of significance:

Table 4 Identified correlations between variables and knowledge barriers

Influencing variable	Knowledge barrier	Rho	Level of significance
Heterogeneity of the department personnel	#01 Insufficient transactive knowledge	0.786	0.036
Heterogeneity of the department personnel	#03 Insufficient internal acquisition of knowledge	0.857	0.014

Table 4 (Cont.)

Heterogeneity of the department personnel	#13 Insufficient culture of learning	0.821	0.023
Physical proximity of the working spaces	# 05 Insufficient concern for knowledge management	-0.808	0.028
Preoccupation with knowledge management	#15 Adverse management conduct	0.772	0.042
Culture of team meetings	#06 Insufficient information storage	-0.866	0.012
Culture of team meetings	#09 Mistrust and micropolitics	-0.866	0.012
Culture of team meetings	#12 Inadequate climate of communication	-0.866	0.012
Heterogeneity of the department personnel	#02 Loss of information	-0.571	0.180
Heterogeneity of the department personnel	#05 Insufficient concern for knowledge management	0.643	0.119
Heterogeneity of the department personnel	#08 Inadequate representation and misunderstandings	0.750	0.052
Size	#05 Insufficient concern for knowledge management	-0.559	0.192
Size	#07 Being professionally blinkered / leaking awareness	0.505	0.248
Preoccupation with knowledge management	#11 Insufficient flow of information	0.733	0.061

4 Discussion and Conclusions

Even though the sample is rather small, significant correlations for two potential influencing external variables and four knowledge barriers could be identified. The claim in the relevant literature for heterogeneous groups or teams to support knowledge transfer corresponds strongly with the first three identified correlations, so that causality seems very likely here.

For the fourth correlation, it seems likely that a distinct physical separation of personnel leads to an increased awareness for knowledge management, so that this barrier is lower in groups that have to handle physical separation.

As already mentioned above, correlations with internally set variables have to be discussed critically as there are only slight differences between the values for the items observed. Yet, it seems plausible that an insufficient preoccupation with knowledge management may lead to adverse management conduct, as well as the conduct of the management may be considered as a consequence of lacking preoccupation with knowledge management. For the correlations of the variable "culture of team meeting", this reasoning also seems to make sense to explain the strong negative correlations: The awareness of the existence and the impact of these barriers may lead to a stronger culture of team meetings in order to overcome these barriers. Admittedly, the deviations in this variable's values are too weak to give any substantiated explanation without further qualitative research.

The medium positive correlations for the variable heterogeneity of the department personnel confirm the causality assumed above, yet the medium negative correlation cannot be explained easily. According to the sample size and the minor level of significance, a statistical impreciseness seems to be more likely than any causality.

The medium negative correlation of the variable “size” and the barrier “insufficient concern for knowledge management” may be explained by the theory that problems in knowledge transfer are more likely with growing group size plus the consideration, that if awareness for this problem exists, means of knowledge management may already have been taken. The medium correlation of department size and the barrier “being professionally blinkered / leaking awareness” can be found to be theoretically expected in the relevant literature and thus can be considered causality. The same applies for the medium correlation of the internally set variable “preoccupation with knowledge management” and the barrier “insufficient flow of information”, although just like the result for the variable “culture of team meetings”, this interpretation is very weak and should also be examined further.

The examined cases have shown that it is hard to distinguish if or which knowledge barriers are really triggered by the potentially influencing variables or are already diminished as a consequence of awareness for these issues.

Hence, further need for research can be identified on the interdependencies between knowledge barriers and the internally set variables as well as between externally and internally set variables. Special attention should be put on viewing organizations as systems with multiple and possibly even changing dependencies (Gomez and Probst 1995), so that these variables could be examined using e.g. maturity degree models.

Acknowledgments. We would like to thank the German Armed Forces for their cooperation and especially for providing all necessary data. The conclusions and views expressed here are our own and should not be attributed to the German Armed Forces.

References

Bullinger, H.-J., Wörner, K., Prieto, J.: Wissensmanagement heute. Daten, Fakten, Trends. Fraunhofer Institut für Arbeitswissenschaft und Organisation. Fraunhofer IRB Verlag, Stuttgart (1997)

Castiglioni, E.: Organisatorisches Lernen in Produktinnovationsprozessen: Eine empirische Untersuchung. Gabler, Wiesbaden (1994)

Davenport, T.H., Prusak, L.: Working Knowledge. How Organizations Manage What They Know. Harvard Business School Press, Boston (1998)

Gomez, P., Probst, G.J.: Die Praxis des ganzheitlichen Problemlösens – vernetzt denken, Unternehmerisch handeln, persönlich überzeugen. Paul Haupt, Wien (1995)

Harmaakorpi, V., Mutanen, A.: Knowledge Production in Networked Practice-based Innovation Processes – Interrogative Model as a Methodological Approach. Interdiscip. J. Inf. Knowl. Manag. 3, 87–101 (2008)

Hopf, S., Prümper, J., Scholl, W.: Fragebogen zur Identifikation von Wissensbarrieren (WiBa). In: Gronau, N., Pawlowsky, P., Schildhauer, T., Schütt, P. (eds.) Wissensmanagement - Motivation, Organisation, Integration. CMP-WEKA, Poing (2005)

Kern, E.-M., Koch, M., Fiechter, C., Richter, A.: Knowledge Barriers in CD&E Projects in the German Federal Armed Forces. In: Tochtermann, K., Maurer, H. (eds.) Proc, Intl. Conf. on Knowledge Management and New Media Technology 2008. JUCS, Graz (2008)

Lehner, F.: Wissensmanagement – Grundlagen, Methoden und technische Unterstützung, 2nd edn. Hanser, München (2008)

Schröder, K.: Mitarbeiterorientierte Gestaltung des unternehmensinternen Wissenstransfers. DUV, Wiesbaden (2003)

Schüppel, J.: Wissensmanagement – Organisatorisches Lernen im Spannungsfeld von Wissens- und Lernbarrieren, Gabler, Wiesbaden (1996)

Senge, P.: Die fünfte Disziplin – Kunst und Praxis der lernenden Organisation, 6th edn. Klett-Cotta, Stuttgart (1998)

Werner, M.: Wissenstransfer in wissensintensiven Dienstleistungsunternehmen – Messung und Identifikation von Einflussfaktoren. In: Engelhardt, C., Hall, K., Ortner, J. (eds.) Prozesswissen als Erfolgsfaktor. Gabler, Wiesbaden (2004)

Wilensky, H.L.: Organizational Intelligence. In: Knowledge and Policy in Government and Industry. Basic Books, New York (1967)

Applied Imagination - *Designing* Innovative Knowledge Transfer Approaches

Leon Cruickshank[1], Alison Mather[2], and Martyn Evans[1]

[1] Imagination Lancaster, Lancaster Institute of Contemporary Arts, Lancaster University
[2] Institute of Entrepreneurship, Enterprise and Development, Lancaster University Management School

Abstract. This paper describes a new approach to the creation of innovative knowledge transfer (KT) activities. This is achieved through the close collaboration of three business schools with a strong record of excellence in KT research and application (Lancaster University, Manchester University and Liverpool University) together with one of the UKs leading centers for design research (ImaginationLancaster, Lancaster University). Operating under the name of IDEAS (Innovation Design Entrepreneurship and Science) this collaboration is active in a wide range of innovation and KT activities. Here we describe how we have applied creative thinking research to the creation (design) of new KT activities and processes. This is achieved through the presentation of a conceptual model; two cases studies of the application of this model and a discussion of future projects and applications.

1 Knowledge Transfer

Knowledge Transfer (KT) has been identified by academics and policy makers as an essential ingredient for innovation and enterprise development, which in turn are important drivers for a competitive and thriving knowledge economy. Over the past several years government reports and policy have highlighted the importance of KT from universities for social and economic benefit. Reports in the UK such as the Treasury's, Lambert Review of Business-University Collaboration (Lambert 2003), The Race to the Top (Sainsbury, 2007) and the Department for Business Innovation and Skills White Paper, Innovation Nation (2008) have been aligned with increased public expenditure on building capacity in universities to increase levels and competences in KT. The Higher Education Funding Council for England (Hefce), for example, has invested £714 million from 2000 to 2008 through the Higher Education Innovation Fund (HEIF) in an attempt to embed KT in the strategies and actions of universities, reveal the beneficial impacts of KT to Higher Education (HE) and industry and thereby increase the salience of KT to university leaders. This, in addition to other national and regional funding initiatives, such as the Science Enterprise Challenge, Knowledge Transfer Partnerships and European Regional development Fund, has increased levels of HE engagement, competence and enthusiasm for the task.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 219–229.
springerlink.com

For the purposes of this paper KT is defined as, 'the iterative cycle of sharing ideas, research results, expertise or skills between interested parties that enables the creation, transfer, adoption and exploitation of new knowledge in order to develop new products, processes or services and influence public policy (Lockett, 2007:12). This definition captures the elements that policy makers are particularly keen to evidence, which are the impacts of KT on innovation and growth in the individual and firm and at regional and national levels, resulting in economic growth and national competitive advantage.

In the light of recent developments in policy and funding, it can be argued that there has been advancement in the development of KT as a legitimate activity for HE, with a more informed and enabled community of practice and with real benefits realised in business and community. However, much of the literature is focused on the elements of KT that relate to Technology Transfer, which is a discreet part of KE activity but by no means forms the majority of HE KT activity in the UK (PACEC, 2009). The differences in the evolution of HE practice are illuminated perhaps by comparison between the US and the UK. The US has higher levels of entrepreneurship in and around universities, easier routes to venture capital and policies such as the 1980 Bayh-Dole Act, which allowed universities to commercialise publically funded research. The result of this was that efforts were focussed on the exploitation of technology and technology transfer. Whilst in the UK there was greater focus on the publication of papers, with the aim of UK universities being to put knowledge in the public domain. (Decter et al 2007).

HEIF and other funding however, has enabled universities to broaden and deepen the scope and reach of KE activity. From the relatively well researched and measured commercialisation of research (development of IP, licensing, university spin outs etc) to programmes where the exchange of knowledge is more tacit and less tangible, with a focus on user led programmes that involve skills development, network learning, sharing of expertise through a variety of mechanisms with large corporations, SMEs and the public sector.

As KT matures as an area of both research and an increasingly important component of economic activity in the UK there is a need for the development of new methods, approaches, processes and activities building on but also transcending traditional and ad-hoc activities. In this paper we are demonstrating how creative approaches have been used to develop new approaches to innovation in KT and how the design of KT opens up new avenues for further development.

2 Design Context, Design Thinking

There is a growing recognition that through the effective integration of design – linking creativity and innovation, and shaping ideas to become practical and attractive propositions for users or customers (Cox, 2005) – companies are more likely to be innovative, become more competitive, increase their profits and boost their performance (Owen, C 2006). There has been a substantial adoption of creative processes in business which is drawing upon the concept of design thinking.

2.1 Design Thinking

Characterised by empathy, integrative thinking, optimism, experimentation, collaboration and visualisation, design thinking can capitalise upon the world shift from industrial manufacturing to knowledge work and service delivery. With the increasing use of designerly approaches, designers are no longer being 'asked to make an already developed idea more attractive to consumers, organisations are asking them to create ideas that better meet consumers desires and needs' (Brown, 2008). Brown claims that the former role is tactical, and results in limited value creation; the latter is strategic, interdisciplinary and leads to dramatic new forms of value. This application across disciplines is a fundamental characteristic of design thinking.

This spread of design thinking into other areas is especially noticeable in the world of business (Verganti, 2006) where design thinking has been closely linked to innovation processes (Utterback 2007; Wylant 2008). Design thinking is now being cited as an attitude rather than an activity where it extends far beyond the traditional design 'picket fence' into an interdisciplinary landscape where it is able to mediate this attitudinal change.

2.2 Design Thinking in Business

There is an increasing emphasis on maximising creativity, mental capital and problem solving in business, especially in western economies with a shrinking manufacturing and raw materials base. 'In order to manage human intellect, managers must enhance their staff's problem-solving abilities and encourage them to share information' (Quinn et al, 2006).

While this really started to be a key issue in the last 10 years or so, the roots of this move can be drawn back to a specific publication in the 1950s. Alex Osbourne was a partner in the advertising agency when he wrote *Wake up Your Mind 101 Ways to Develop Creativeness* (Osbourne, 1952). Many of the key concepts not only in creativity and knowledge exchange techniques in business, but also design education can be traced back to Osbourne's primer for the corporate world and the commercial/academic community of research that developed around this. In 1952 Osbourne developed techniques such as brainstorming and started the development of an approach called Creative Problem Solving (CPS) concentrated in a research group in Buffalo State College. The result has been a series of iterations in 6 major phases of CPS including Osbourne-Parnes five stage CPS model (v2.2) (Parnes et al, 1977). While this may not be immediately familiar, underpinned by ongoing empirical research this introduced the idea of phases of convergent and divergent thinking in the creative process that is common currency in design process discussions. Later iterations of CPS stress a careful balance of convergent/divergent or imagination and judgment (Treffinger, 1982). The latest iterations of CPS promote a constructionist educational perspective incorporating an adaptive, user centred 'meta-components' approach (Selby, 2004). This is non-linear process of understanding challenges, generating ideas, planning and preparing for action.

While CPS resonates either directly or indirectly through much published writing in design thinking, there are many other creativity models and frameworks, some are similarly underpinned by research e.g. TRIZ (Orloff, 2006), Prince2 (Bentley, 2005) or more informal descriptive publications for business such as those produced by the multinational design agency IDEO (Kelly and Littman, 2004; Kelly and Littman, 2005).

Operating within these frameworks there are a multitude of creative problem solving techniques. The most familiar of these would be de Bono's lateral thinking approaches (de Bono et al, 1990), but there are many more. The innovation company Mycoted provides a free online resource of over 400 techniques divided into categories such as idea generation, problem definition, and idea selection (Mycoted, 2009).

2.3 Design and Knowledge Exchange

The approaches described in 2.2 are increasingly being used, not just in traditional areas such as product design but also in a more integrated, holistic manner under the umbrella term service design. Design is no longer about 'doing', it is now about 'thinking' what and how to do (Kelly 2005). Strategic engagement of design at a national level through bodies such as the UK's Design Council is increasing, from a standing start with the national *Designing Demand* programme now well established promoting the application of design skills in SMEs (Design Council 2007). A more exciting approach is seen in the recently launched *Innovate for Universities* programme that places experienced designers with knowledge transfer offices in universities with a proven track record in innovative KT. This follows on from a pilot project with Isis (the Oxford University KT centre), that demonstrated a significantly higher success rate in spin out companies that had the benefit of design thinking as they spun out of Oxford compared to those with the traditional support offered (Design Council 2009).

Both these initiatives are successful within the established KT frameworks for companies and universities. As a result they share strengths and weaknesses common to this area (as we go on to describe in the following section). Our interest in this paper is to describe how we are using design to develop innovative new KT frameworks rather than operating within orthodox processes that have already been well established and proven (e.g. KTPs, innovation vouchers, placements).

3 The IDEAS Partnership

Within the context of KT development and design thinking the IDEAS (Innovation Design Entrepreneurship and Science) Partnership is working to develop new applied approaches. The IDEAS Partnership involves representatives from the three constituent management and business schools in the North West, namely: Lancaster University Management School (LUMS; together with ImaginationLancaster and Lancaster Institute of Contemporary Arts), University of Liverpool Management School (ULMS) and Manchester Business School (MBS; with the

Manchester Institute of Innovation Research (MIoIR)). IDEAS works and collaborates with the Daresbury Science and Innovation Campus (DSIC) Limited, the Science and Technology Facilities Council (STFC), which hosts and runs the large scale Daresbury Laboratory facility, and the North West Regional Development Agency (NWDA). The Partnership has, in addition, received support and advice from the Economic and Social Research Council (ESRC), the TSB (Technology Strategy Board) and the North West Universities Alliance (NWUA).

The IDEAS Partnership is based on the fundamental premise that there are a number of areas where a joint initiative and collective partnership between the three Schools and their partners through working more effectivly together rather than the Schools working on their own.

The key aim of IDEAS is to help establish and enhance the performance of firms and organisations, our operational aim is to develop put 'new ideas into practice' through research and knowledge transfer activity centered on innovation, competitive performance and economic development. Within this overarching aim there are four key objectives for the Partnership which can be seen to operate at a number of different scales, namely to:

1. develop new models;
2. develop new approaches;
3. new skills and worker profiles; and,
4. new metrics, mapping and evaluation techniques.

The KT-*design* component of IDEAS activities is lead by Lancaster University, exploiting its strong track record of innovative KT. Specifically this includes, the Institute for Entrepreneurship and Enterprise Development (IEED) which focuses on entrepreneurial learning, small firm innovation and leadership and developed KT programmes that support leadership and enterprise development capability within SMEs.

Studies have been conducted that explore the regional impact of a university through the creation of jobs and expenditure of students and staff (Robson et al, 2002). However, there has been little research in to the potential forward linkages (Felsentein, 1996) arising from the presence of a university within a region (Cox and Taylor, 2006). Cox and Taylor suggest that there are considerable forward linkages effects of Lancaster's engagement with SMEs with, 'steady state estimates of the annual impact of regional income of £1,278,000' (Cox and Taylor).

This initial research into the efficacy of IEED's approach to KT was further evidenced by Wren and Mason, in their analysis of the impact of IEED's leadership programme, LEAD (Leading Enterprise and Development) on SME participants. The LEAD programme was recently commended as an example of effective business and management provision to SMEs in the Department for Business Innovation and Skills report, 'Engaging for Success: enhancing performance through employee engagement,' (MacLeod and Clarke, 2009).

This is complimented by ImaginationLancaster, one of the UKs leading research centres for design thinking (=3rd nationally for Art and Design in the recent RAE exercise), researchers here have expertise in the application of design thinking to real world applications and in the facilitation of KT through creative interventions.

4 Designing KT in Practice Case Studies

This section briefly presents two case studies that detail our approach to designing KT activity through collaborative, practice-based, interactive events that we call ImaginationLabs. Here the two case studies of KT through ImaginationLabs address wholly differing areas of concern but were underpinned by a shared methodology of designing creative problem solving frameworks that participants are able to inhabit:

- *Mott MacDonald* is a management, engineering and development consultancy serving the public and private sectors worldwide. (www.mottmac.com)
- *Dare Digital* are an award winning interactive marketing agency (www.daredigital.com)

Imagination Labs are KT events are developed in collaboration with participants. Our approach is to develop agendas in partnership with their participants that not only address what they want, but what they need. Design thinking is employed to challenge norms and enable participants to feel comfortable upon uncertain ground.

The development of an ImaginationLab shares numerous characteristics with the design process and broadly follows the following four-stage Designing Creative Frameworks (DCF) process. Each of the stages consists of a series of iterative loops where exploration and testing of ideas can happen:

- *Discover:* Here potential strategies for achieving the overall goals of the KT event are explored in an open and exploratory manner. A divergent process where multiple options are considered and evaluated against the practicalities and resource implications.
- *Define:* Establish critical parameters and confirm with commissioning organization.
- *Develop:* Here we enter into an iterative loop where KT approaches are refined through prototyping and testing.
- *Deliver:* Materials (prompts, exemplars, proformas, examples, etc) are created and finalized for use in the ImaginationLab.

The development of each event carefully responds to participant characteristics, such as group dynamics or personal agendas, and is conceived with flexibility and the ability to adapt the agenda 'on the fly' as required. A number of eventualities will have been considered during the development process but experience has shown that facilitators need to be willing to adapt the schedule, focus and potentially outcomes during the delivery of these events.

This process recognises the role (and sometimes the necessity) of dysfunctional behavior, non-linear approaches and shifting goals. We also try and engage with participants before, during and after the Imagination Labs in a more collaborative, co-creating approach than conventional facilitation, working with groups to create a framework for action that is specific to them and created by them (in collaboration with other actors). A pertinent analogy is that through working with organizations to create their own tools and techniques - we are not just giving organizations nets not fish - we are giving organisations the ability to make more and better nets themselves. This approach is reflected in both the case study and conceptual overview of our process, described below.

Table 1 KT Design Case study details

Organization: Mott MacDonald	**Dare Digital**
Duration: One Day	**Duration:** 3 Hours
KT Aim: To explore how future developments in ICT can help communication of health issues to clients of Walsall Primary Care Trust (PCT) specifically pregnant teenagers and cardiac patients.	**KT Aim:** To develop new innovation structures in the company integrating technical and creative departments more productively
Participants: 5 academics, 5 postgraduate students, 6 Mott McDonald, 2 Walsall PCT **Location:** Lancaster University **Duration**: 9:30am – 4:00 pm	**Participants**: 2 academics, 25 Dare creative department, 10 Dare technical department, 4 Dare management **Location:** Dare Digital (London) **Duration:** 4:00 am – 7:00 pm
Distinctive Features	
Externally Focused - effecting composition and activities of the lab. - students, academics, 3rd party consultants and clients contributed to the day workshop - there was a proportionally small representation from the actual client - in activities groups started by creating personas of the stakeholders and addressing further ideas towards meeting the needs of these fictional people.	**Internally Focused** There were only people from Dare at the presentation with an Imagination researcher and a design visualizer. - A broad range of the company hierarchy contributed from Board members to junior designer/ technicians - There was minimal use of abstraction devices such as personas – most comment was addressing direct experience. - There was a degree of sensitivity about the content of the lab.
Detached, objective consensual approach We built on the culture of empathy and understanding brought by the main stakeholders and the predicted reserve felt by people coming together for the first time. - The serious subject area, strong social worker component in the group and ultimately representing social groups not present in the lab. (for example we chose not to have pregnant teens in our lab.) required a more serious, reflective, respectful approach.	**Challenging (Socratic) approach** - As a creative agency, a robust, open dialogue about ideas is the norm; we employed devices such as 'critique' familiar to the group. - We encouraged free thinking and expression and genuine responses (one post-it labels the technical Department as 'Idea Nazis'). A lot of humour was employed by participants (and encouraged by us) to defuse personal attacks but still communicate the issues. This was built into the event through a 'caricature' exercise.

4.1 Feedback and Interim Conclusions

The participants from the ImaginationLabs (Mott MacDonald and Dare Digital) directly provided feedback to the workshops that enabled a first stage of evaluation to be undertaken. Mott MacDonald identified: transferable KT approaches (such as the development of 'Personas' to humanize their stakeholders) that would be applicable to much of their business activity; the use of divergent and creative thinking techniques successfully 'challenging the norms' and often widely help assumptions; and the benefit of team-based problem solving to address complex challenges. Dare Digital identified: the need to develop new systems of innovation as core to a sustainable future; that the event highlighted tensions between the various functions within the organization (particularly the 'techies' and the 'creatives'); and that the event provided new and more junior staff to feel that they had a voice within the organization. As these case studies have only been recently undertaken, further analysis and evaluation is planned in the future.

The feedback from both Imagination Labs demonstrate the potential for the KT approaches we employed to have a life beyond the specific event, with the potential for high impact over a long period of time.

5 Designing KT Frameworks: Conceptual Overview

There are a number of key characteristic that underpin, and help to guide the development and implementation of, ImaginationLabs. In line with Archer (1963), Clarkson & Eckert (2005), Pugh (1990) and Lawson's' (1997 & 2004), observation that that at an abstract level, there is a central core of generic stages that constitute a commonality between design processes, the development of the DCF conceptual model revealed a series of iterative and interrelated activities. In line with Goel's (1995) observation that design development occurs in distinct phases, the DCF conceptual model has been divided into a number of phases, namely: Inputs; Designing Creative Frameworks; ImaginationLab; and Outputs.

- *Inputs:* understanding of the priorities and expectations of stakeholders as well as the scope and remit of the project.
- *Designing Creative Frameworks*: A four-stage process (Discover, Define, Develop, Deliver) utilizes divergent and convergent approaches, in an i*terative manner, to explore,* develop, refine and manifest the facilitation approach.
- *ImaginationLab:* The implementation phase of the project through a participatory workshop. Even at this stage there is often the need to be reactive to a variety of parameters, such as group dynamics or personal bias, to ensure the relevance and validity of the activities, and that the overall project goals are being met.
- *Outputs:* The outcomes of the process can be varied and are appropriate to the goals of the project as set out in the Inputs phase. As our approach can encompass a variety of project, this phase is not prescriptive and can be adapted to the audience and available resources.

The use of divergent and convergent thinking, undertaken in an iterative manner, is core to our design of KT approachs. This approach resonates with Osbourne-Parnes Creative Problem Solving methodology (Parnes et al, 1977), particularly in terms of convergent and divergent phases of thinking in the creative process. As a key characteristic of design thinking, creating many options (diverging) and then narrowing them down into their options (converging) is clearly evident in our approach. This is well proven as a requirment for the generation of innovative, creative solutions, (Alexander, 1962; Dubberly, 2004) Banathy (1996) identifies the consideration of a number of inquiry boundaries as fundamental to the divergent approach in terms of establishing core values for the project.

5.1 Potential Strengths of Design Approach to KT

The evidence from activities with MottMcDonald, Dare Digital and ongoing work with the Daresbury Network in addition to parallel conceptual development briefly described above gave us confidence that designing KT was a productive area for further investigation, and to continue the integrated approach of hands on KT inexorably linked with ongoing research into KT innovation. The result was the two-year HEIF funded project as described below.

6 Implications and Next Steps

We contest that the design of KE represents a new dimension of knowledge exchange activity. To establish this proposition we are undertaking a new project specifically aimed at devising some of the foundational concepts of KT design and through the application, testing and evaluation of these fundamentals create highly innovative new KT approaches. This will be achieved through a project called, Creative IDEAS. Using participatory design methods to create new KT tools, services and (possibly) products. These new approaches will be demand-led manner with the active collaboration of industrial partners focusing on large corporates and their interaction with HEIs and SMEs. This combination of creative and business expertise also chimes with regional (NWDA 2008), national policy priorities (Denham 2008, Sainsbury 2007, Cox 2005) and research funding agendas (TSB, Design Council).

In Creative IDEAS we will develop a series of pilot events specifically tailored to the relationships, issues and opportunities identified in stages one and two (described in figs.2 and 3). These will lead to more substantial programmes with key corporate partners. Activities will draw on existing experience in KT within Lancaster University (for example action learning, work exchanges and residential workshops). These range in duration from half-day to a full week to a diffuse action that spans one or two months.

Of particular interest to Creative IDEAS is the potential impact of knowledge transfer (activities and programmes) between HE, larger corporations and SMEs. The perception of policy makers is that SMEs are major contributors to the economy, driving innovation, the development of new technologies and creating employment. (www.cric.ac.uk/cric/compprojects/project-5.htm). However, the value of the contribution of SME based innovations tend to be lower than that of larger firms (Tether, 1998) and the performance measures such as job creation and growth are often at odds with the strategies and realities of innovative high tech firms, many of which, have modest levels of employment creation, innovations which are not applicable to the wider market and no ambitions for high growth. www.cric.ac.uk/cric/compprojects/project-5.htm). Both large and small firms are important to innovation and need support. Creative Ideas will attempt to build an innovation network (Autio 1997), where large and small firms come together to maximize innovation opportunity.

It is through projects such as Creative IDEAS, and the wider IDEAS collaboration that can develop, validate and share new approaches, not only to KT delivery but also in the methods users to create new approaches to KT.

References

Alexander, C.: Notes on the Synthesis of Form. Harvard University Press, USA (1962)

Archer, B.: Systematic Method for Designers. Design Magazine, UK (1963)

Banathy, B.: Designing Social Systems in a Changing World. Plenum, New York (1996)

Bentley, C.: Practical PRINCE2. The Stationery Office, UK (2005)

Brown, T.: Design Thinking. In: Harvard Business Review, US, June 2008, pp. 84–95 (2008)

Chesbrough, H.: Open innovation: A new paradigm for understanding industrial innovation. In: Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford (2006)

Clarkson, P., Eckert, C. (eds.): Design Process Improvement. Springer, London (2005)

Cox, G.: The Cox Review of Creativity in Business. HM Treasury, London (2005)

De Bono, E., Unit, S., College, C., Education, C.: Lateral thinking. Penguin Books (1990)

Decter, M., Bennett, D., Lesure, M.: University to business technology transfer – UK and USA comparisons. Technovation 27, 145–155 (2007)

Denham, Innovation nation. Crown Copyright 2008 (2008)

Dubberly, H.: How Do You Design? A Compendium of Models (1994), `http://www.dubberly.com/wp-content/uploads/2008/06/ddo_designprocess.pdf` (accessed November 11, 2008)

Design Council, Designing Demand: Make design deliver lasting success for your business. Design Council, UK (2007), `http://v35.pixelcms.com/ams/assets/dcone284152/DD_Brochure.pdf` (Accessed August 20, 2009)

Design Council (2009), `http://www.designcouncil.org.uk/en/Design-Council/1/What-we-do/Our-activities/Design-for-technology-transfer/` (accessed Online August 2009)

Goel, V.: Sketches of Thought. MIT Press, Cambridge (1995)

Hippel, E.: Democratizing Innovation. MIT Press, USA (2005)

Kelley, T., Littman, J.: The art of innovation. HarperCollinsBusiness, New York (2004)

Kelley, T., Littman, J.: The ten faces of innovation: IDEO's strategies for beating the devil's advocate & driving creativity throughout your organization. Profile Books (2005)

Lambert Review of Business- University Collaboration, HM Treasury Department for Education and Skills (2003)

Lawson, B.: What Designers Know. Architectural Press, Oxford (2004)

Lawson, B.: How Designers Think. Architectural Press, Oxford (1997)

Leadbeater, C.: We-Think: The power of mass creativity. Profile, UK (2007)

Lockett, N., Kerr, R., Robinson, S.: Multiple Perspectives on the Challenge for Knowledge Transfer between Higher Education Institutions and Industry 'Multiple perspectives on knowledge transfer between higher education institutions and industry. International Small Business Journal 26(6), 661–681 (2008)

Mycoted (2009), Mycoted website, `http://www.mycoted.com/mwiki/index.php?title=Mycoted:About&oldid=3029` (accessed January 10, 2009)

NWDA 2008

Orloff, M.: Inventive thinking through triz: A practical guide. Springer, UK (2006)

Osbourne, A.: Wake up your mind: 101 ways to develop creativeness. Scribner (1952)

Owen, C.: Design Thinking: Notes on Its Nature and Use. Design Research Quarterly 1(2), 16–27 (2006)

Parnes, S., Noller, R., Biondi, A.: Guide to creative action. Scribner (1977)

Pugh, S.: Total Design: Integrated Methods for Successful Product Engineering. Addison-Wesley, Reading (1990)

Quinn, J., Anderson, P., Finkelstein, S.: Managing professional intellect. Harvard Business Review on Knowledge Management, 181–205 (1998)

Sainsbury, The race to the top: A review of government's science and innovation policies Crown copyright (2007)

Selby, E., Treffinger, D., Isaksen, S., Lauer, K.: Defining and assessing problem-solving: Design and development of a new tool. Journal of Creative Behavior 38, 221–243 (2004)

Taylor, J., Cox, S.: The Impact of a Business School on Regional Economic Development. Local Economy 21(2), 117–135 (2006)

Treffinger, D., Isaksen, S., Firestien, R.: Handbook of creative learning. Center for Creative Learning (1982)

Verganti, R.: Innovating through design. Harvard Business Review 84(12), 114 (2006)

Wylant, B.: Design thinking and the experience of innovation. Design Issues, vol. 24(2) (Spring 2008)

Utterback, J., Vedin, B., Alvarez, E., Ekman, S., Sanderson, S.W., Tether, B., et al.: Design-Inspired innovation. World Scientific Publishing Co. Pte. Ltd., London (2007)

Knowledge Transfer Partnerships at the University of the West of England

Gareth R.T. White, Xiaojun Wang, and Ian Freeth

Bristol Business School, University of the West of England,
Frenchay Campus, Bristol. BS16 1QY. United Kingdom
e-mail: gareth.white@uwe.ac.uk

Abstract. This paper outlines the range of Knowledge Transfer Partnerships (KTPs) undertaken by The University of the West of England and discusses two typical cases in detail. It presents the planned and unplanned benefits that have been identified and realized.

In addition to the organizational improvements we identify the value of KTPs to those employed by the programme in the form of formal qualifications and transferable skills.

Furthermore, we discuss the research opportunities that KTPs provide and the associated benefits for the university and organization involved, as well as other possible advantages for academics and university students.

We also identify the challenges that universities face in attracting and supporting future KTPs.

1 Introduction

Knowledge Transfer Partnerships (KTPs) offer an attractive way for universities and enterprise to collaborate. Typically, university graduates are employed as KTP Associates to undertake a substantial piece of work for an organization under the guidance of a Workplace Supervisor and a Lead Academic. Not only does the KTP provide the organization with a dedicated resource to complete a significant project but it also provides access to a university's store of knowledge and experience. The university gains the opportunity to inject its expertise into the commercial environment directly and to engage in further research. Additionally, the Associate gains valuable vocational experience and is supported through a programme of further study resulting in nationally recognized qualifications including the opportunity to study for a higher degree.

Being part funded and not requiring the diversion of existing human resources away from current organizational activities KTPs have significant advantages over other more traditional consultancy arrangements, particularly for small to medium sized enterprises (SMEs).

Although the benefits of KTPs can be very attractive, it must be stressed that to exploit the opportunities that they can provide to all stakeholders, there needs to

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 231–238.
springerlink.com

be a realization that they must be pro-actively sourced and managed. It is therefore essential to consider the potential barriers to collaboration, many of which are internal to universities. Some of those initial barriers which need to be addressed include staffing resources, marketing and business development capabilities and the important aspect of identifying and matching skills and knowledge requirements. These factors are important so that universities are seen to have a credible and professional approach to supporting business organizations in achieving their goals and objectives.

This paper outlines the current KTP activities of the Bristol Business School at the University of the West of England (UWE), showing the wide variety and scale of projects that are undertaken. It discusses the goals and achievements of two current KTPs in detail and highlights the unexpected and intangible benefits that have resulted. Finally it presents the value of KTP activity to universities and their staff, in particular, as research opportunities and as rich sources of teaching materials.

2 The University of the West of England

UWE has a history of successful KTPs with local and international businesses (http://rbi.uwe.ac.uk/intranet/business/ktp.asp). The department of Strategy and Operations Management currently supports three out of the five KTPs that are being undertaken within Bristol Business School at the university. Table 1 indicates the types of businesses where these KTPs are in progress and the nature of the project work.

The projects range in value from £100,000 to just over £200,000 each with projected savings and benefits of up to £2.6 million over 5 years. Between 50% and 67% of the funding is provided predominantly by the Technology Strategy Board (TSB) with some additional support from the Economic and Social Research Council (ESRC), the remainder being provided by the host organization.

Table 1 KTP Businesses and Projects

Business Type	KTP Activity
Rural, Non-Profit	ISO9000 / EMAS Certification
Retail, Equipment Service & Maintenance	IT Systems Development
Sports Equipment, Design & Manufacture	Supply Chain Development
Marketing Services	Marketing Technologies Development
Food Distribution	Supply Chain Development

3 Rural, Non-Profit (RNP)

RNP has engaged in a series of KTPs and this is perhaps the best evidence of their real-world benefits. Originally targeted with improving its marketing strategy and activities the later KTPs have grown to encompass business-wide changes to their quality and operational systems and practices.

In 2005 the organization began working toward achieving ISO9000 certification; a considerable undertaking for a non-profit enterprise that operates in a sector where international or industry standards of excellence are not commonplace. Preparation for certification required thorough investigation of the existing business processes. The relatively simplistic method of Business Process Mapping [4] was chosen for this purpose; suggested by the Lead Academic for the project whose knowledge and experience of continuous improvement, ISO9000 and business consultancy were well aligned to the KTP's aims.

While mapping the business processes numerous opportunities for immediate improvement were identified, ranging from updating accounting software to simplification of manual processes and the elimination of redundant activities. This approach also enabled the implementation of previously unrealized opportunity such as the initiation of online ordering: this was particularly welcomed by the Chief Executive who commented "*it's wonderful, we did £25k of business last night while we were all asleep!*".

One of the most significant hurdles that had to be overcome was the current employees' resistance to change. Many of the staff had little exposure to modern business management methods, having worked at RNP for the majority, if not all, of their careers. In spite of considerable training and communication there were many 'moments of truth' when individuals were finally faced with the task of redesigning and improving their working practices. Such instances introduced delays and placed further demands upon the KTP Associate. Without the KTP Associate it is likely that these planned developments would not have been made or would have at least taken considerable longer to be completed. The Associate's experience of modern business and focus on the overall project goals enabled the changes to be made.

KTPs also offer a surprising degree of flexibility which is essential for those businesses that operate in shifting and unpredictable environments. While working toward ISO9000 certification its ultimate value to the organization was brought into question [7] and the Eco-Management and Audit Scheme (EMAS) was identified as a recognized achievement that would probably have greater direct benefit to a rural non-profit organization. Consequently the project was amended and extended to work toward gaining EMAS certification.

Although the project's ultimate aim had changed the fundamental tasks of understanding and improving the core business processes and practices remained. The Associate has acquired widely transferable skills by enrolling on the university's modules in project management and communication training. This has aided the new project's rapid progress and the organization has recently successfully navigated the first formal audit of the new procedures and practices.

One of the main difficulties encountered during the initial phases of the project was due to the implementation team comprising such a varied number of personnel from across most of the organization's departments. It was in fact extremely difficult to arrange meetings when everyone was available. The Associate's use of information technology, predominantly in the form of email, was invaluable in communicating the proceeds and resulting action plans from each meeting thus maintaining project momentum.

Toward the end of the project the issue of sustainability of the EMS became increasingly important: how would the momentum and good practices be maintained when the KTP Associate had left the organization? Whilst the implementation team comprised people from most departments thus ensuring that understanding of the systems were spread throughout the organization, there was a need and desire to ensure that environmental management was something that was embraced by everyone, as a philosophy rather than as 'something that other people did'. Again, the Associate's use of information technology in the form of mass email communications assisted in keeping everyone abreast of developments and highlighting awareness of new procedures. Also, by publishing the implementation team's project GANTT chart complete with task details and the name of the responsible team member, the importance of the project was communicated to all employees. Additionally, tasks that were completed on schedule were highlighted with a 'happy face' graphic ☺, whereas tasks that were behind schedule were highlighted with a 'sad face' graphic ☹. This was a useful motivator for the members of the implementation team and was a simple way for other employees to understand how the project was progressing. In fact, every employee effectively became a project supervisor and thereby became closely interested and involved in the project and its successful and timely completion. In order to fully cement the new working practices RNP and UWE are in the process of initiating a further short-KTP. Not only is this further evidence of the effectiveness of KTPs but the extension to the project will itself form a component of the EMAS objective evidence and demonstrates the organization's commitment toward environmental improvement.

The cost and value of ISO9000 to small businesses has received much attention by academia and our work has added to the understanding that it remains a significant challenge to SMEs, particularly non-profits [7]. Similarly, there is little theoretical analysis of the implementation of EMAS and the current KTP is providing valuable insights into that process.

One of the key reasons for pursuing EMAS was its perceived marketable value to the organization. While it is difficult to give this a precise figure we can confirm that a significant contract was gained as a consequence of RNP being able to materially demonstrate its commitment to environmental concerns. Furthermore, the improvements to date, expressed in Table 2 as operational benefits, could be communicated in the annual EMAS disclosure in terms of its environmental benefits. The financial benefit is of concern to the organization but this could be expressed in volume or units of gas, electric, water and wastes consumed or produced. For example, changing the general waste disposal contractor provided no financial benefit but has resulted in the organization increasing the proportion of general waste that it recycles by 82% over the previous year. This form of disclosure would be of greater interest to environmental stakeholders, particularly public stakeholders, and thereby be more likely to have some positive marketable value.

Table 2 Benefit Realization

	Costs and Initiatives	**Benefit** (cost reduction on previous year)
Gas	£0	14.8%
Electricity	£minimal Ongoing replacement of lighting to low-energy types	13.7%
Water	£0	45.8%
Drainage and Sewerage	£15,000	87.2%

In addition to the measurable benefits are numerous indirect and intangible achievements. A formal method of managing projects has been brought into the organization via the Associate. Also, and much to the amusement of the Associate, was the Lead Academic's delight upon hearing that he had replaced the battery in the company clock: the clock had been out of action for many years. This is a seemingly innocuous change but one that had been immediately recognized and appreciated by the company staff and, in the Lead Academic's experience, is one that is an effective way of demonstrating commitment to organizational change and improvement.

It is important to appreciate the scope of opportunity that this KTP project has provided. In addition to being a valuable opportunity for researching the business practices of rural, non-profit SMEs it has also been the focus of the Lead Academic's doctoral studies. The KTP has provided a framework for university-commerce relations that go beyond its immediate objective of completing an industry-based project. Similarly, KTPs undertaken by other faculties within UWE have provided opportunity for graduate students to engage in real-world work. Not only does this improve the graduate's employability and provide a realistic context for their studies and dissertations but the organization benefits from access to further resources and expertise.

4 Food Distribution (FD)

The KTP project with FD started in October 2008. FD stores and distributes a range of frozen, chilled and ambient food, including fresh meat products, in the South West. Its customer base includes pubs, clubs, hotels, hospitals, nursing homes, restaurants, supermarkets and others. Whilst FD has a loyal customer base and a regional reputation for good service the company is finding increasingly that business is won or lost on price, particularly with public sector clients. In addition, competition is being experienced from national distribution companies who operate on a much larger scale. FD believes that it is strategically important to differentiate the range it offers both from national distributors and other regional competitors.

While more and more consumers start to consider the local factor in their purchasing decision, positive claims about the environmental and social benefits of 'local food' systems are increasingly common [6, 3]. Supporters claim that 'local food' serves to reduce food miles and greenhouse gas emissions, improve food safety and quality, and provide a chance for supporting the local economy. The company believes that there is an opportunity to differentiate the range it offers from its national competitors by offering 'locally sourced' food to both existing and new customers in the region. The KTP partnership will enable FD to effect a culture change towards a more locally-focused business, whilst maintaining its traditional values of service.

One key part of the project will be gaining a full academically informed understanding of regional customer requirements, demand and pricing for locally sourced food, and supplier requirements and capabilities. However, as Edwards-Jones [3] indicated, how far food has travelled (food miles) is a poor indicator of the environmental and ethical impacts of food production. The benefits of local food can only be assessed by combining spatially explicit life cycle assessment with analysis of social issues. It is essential for FD that the competitive advantage through the promotion of locally sourced products should be sustainable and that their current processes can support the operational implications if locally sourced products are introduced.

The first stage of the project is to look at FD's existing supply chain and develop new distribution and logistics processes to accommodate a greater proportion of chilled (rather than frozen food) and substantially increased numbers of smaller customers and suppliers. Value stream mapping tools were chosen to map the end to end supply chain. Through the supply chain mapping, the Associate identified that for some products such as frozen chips, no value is being added for the vast majority of time that products are within the defined supply. In addition, the internal lead times are, on average, long, with supplier lead times considerably shorter. It also showed that there is a very high level of available stock which results in low stock turnover rate, and there is a fundamental dislocation between actual demand and actual purchases required. Although many factors contribute to the high stock level, such as suppliers' promotion and long product shelf life, further analysis indicates that for a single product line, FD could save up-to £17,000 if customer demand, ordering cost, stock holding cost, and price discount were incorporated into the ordering quantity decision making process.

Through the value stream mapping and analysis of different operations process using role activity diagrams, the Associate identified that in the butchery section, the processes used to fulfill a meat order are labour intensive and that a significant amount of time is spent on each order that did not add value. The analysis also highlighted that the current process is prone to error at a number of points due to the reliance on butchers to complete an order from start to finish. The Associate also found that the main causes for the discontinuation of some newly launched chilled products are low shelf life, high minimum order quantity and low demand.

These criteria could be considered in the decision-making of launching new chilled products in future.

Overall, the analysis highlights that there is a requirement within the business to pay closer attention to its operations. Although the KTP project is still in its early stage, a number of recommendations have been made based on these findings. The majority of these recommendations can be quickly implemented and are expected to bring significant benefits to FD.

5 Conclusion

KTPs are capable of delivering significant bottom-line benefits to organizations and may be more attractive than other consultancy arrangements, particularly for SMEs. Not only are they capable of delivering substantial benefits, such as achieving EMAS certification or re-engineering supply chains, but also of identifying and implementing other unexpected tangible and intangible benefits.

The cases outlined above are significant projects, greater in scale than perhaps many SMEs would consider embarking upon. Shorter KTPs for projects of between 10 and 40 weeks are now available, providing greater flexibility and attractiveness to smaller enterprises.

Successful KTPs are capable of becoming serial events and as such should be viewed as long-term, even lifelong, relationships between university and local organizations. Their value therefore lies beyond the immediate deliverables of the current or initial project. Furthermore, the scope of opportunities for other collaborations should not be underestimated. For universities and their staff, KTPs offer stimulating working environments, valuable research opportunities and widening networks and contacts. For university students, partner organizations may provide real-world experience that adds significantly to their employability. KTPs may also be a source of interesting cases for students to study, particularly since they are likely to involve organizations with which the student is familiar.

KTP income is a contributor to the Research Assessment Exercise (RAE), one may also consider how knowledge transfer between university and industry may be further recognized and developed for future Research Excellence Framework (REF) assessments. Ultimately KTPs and other knowledge transfer mechanisms are drivers for collaboration that is seen as a necessary dimension of both regional and national economic and intellectual success for the future [1, 2, 5].

The growing importance of university-commerce knowledge transfer will require universities to maximize their presence within local and regional business environments. It will become increasingly important to be able to provide the wide range of appropriately skilled and experienced academic resources that organizations require. Possession of such an eclectic resource may be the competitive advantage that enables a university's collaborative efforts to flourish. Consequently, there is a need to recognize the specialized combination of consulting, researching and teaching that some academics perform in supporting knowledge transfer initiatives. For maximum long-term effectiveness this ultimately necessitates specific recruitment strategies and reward opportunities.

References

1. Abd Razak, A., Saad, M.: The role of universities in the evolution of the Triple Helix culture of innovation network: The case of Malaysia. International. Journal of Technology Management and Sustainable Development 6(3), 211–225 (2007)
2. Cooke, P.: Knowledge Economies: Clusters, learning and cooperative advantage. Routledge, London/New York (2002)
3. Edwards-Jones, G., Canalsb, L.M., Hounsomec, N., Truningerd, M., Koerbera, G., Hounsomee, B., Crossa, P., Yorka, E.H., Hospidob, A., Plassmanna, K., Harrisa, I.M., Edwardse, R.T., Dayd, G.A.S., Tomosc, A.D., Cowellb, S.J., Jonesa, D.L.: Testing the assertion that local food is best: the challenges of an evidence-based approach. Trends in Food Science & Technology 19, 265–274 (2008)
4. Hines, P., Rich, N.: The Seven Value Stream Mapping Tools. International Journal of Operations and Production Management 17(1), 46–64 (1997)
5. Morgan, K.: The Learning Region: Institutions, Innovation and Regional Renewal. Regional Studies 31, 491–503 (1997)
6. Morgan, K., Marsden, T., Murdoch, J.: Worlds of food. Place, power and provenance in the food chain. Oxford University Press, Oxford (2006)
7. White, G.R.T., Samson, P., Rowland-Jones, R., Thomas, A.J.: The Implementation of a Quality Management System in the Not-for-Profit Sector. The TQM Magazine 20(3), 273–283 (2009)

The Yorkshire Enterprise Fellowship Scheme

Lindsay J. Georgopoulos and Suzanne Emmett

YTKO Consulting Ltd, Round Foundry Media Centre, Foundry Street, Leeds, LS11 5QP
e-mail: lindsay.georgopoulos@ytko.com, suzanne.emmett@ytko.com
www.ytko.com or www.yef.org.uk

Abstract. A much-favoured strategy to strengthen the UK economy is to exploit more of the world-class research being carried out in universities. This requires increased collaboration between universities and the industry sector and will benefit enormously from arming academic researchers with tools and knowledge necessary to commercialise their ideas.

Here we describe the operation and success of a recent initiative from one of the Regional Development Agencies, Yorkshire Forward, namely the Yorkshire Enterprise Fellowship. This Fellowship provides business and personal development training to academic and clinical researchers as well as continuous one-to-one mentoring support and a financial contribution to progress commercialisation of the researcher's idea.

The programme will accelerate the commercialisation of research from the participating universities and embed an entrepreneurial culture within the scientific community. This paper details several examples of best practice that can be used for similar schemes in other disciplines and in other geographical areas.

1 Background

In recent years, the commercialisation of university research has attracted increasing attention as a strategic means to enhance UK productivity and economic growth. The topic gained particular attention and momentum in 2003 following the publication of Richard Lambert's independent review of business-university collaboration [1], which detailed a number of ideas to progress the interaction. There is no doubt that the research that is carried out in UK Higher Education Institutes (HEIs) is world-class. However, this research excellence has not been translated into economic success as optimally as in the USA [2]. One of the key industries that will play a role in strengthening Britain's future economy as well as meeting future challenges such as a growing ageing population is life sciences [3]. Bringing these facts together, we need to demonstrate the social and economic benefits of investing public money in science and technology industries as well as increasing co-operation between UK HEIs and the industry sector. In addition, the

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 239–247.
springerlink.com

limited options for post-doctoral researchers to have a long career in academia means that there needs to be more effort exerted into training and helping enthusiastic academics make the transition from academia to industry. This will be helped enormously by the implementation of the new Research Excellence Framework (REF), which will take into account the economic and social impact of research as well as publication records.

Local strategies such as the Regional Economic Strategy for Yorkshire and Humber 2006-2015 have aligning goals, for example the aim to generate more start-up businesses and increase R&D expenditure over the course of 10 years [4]. Our local Regional Development Agency (RDA), Yorkshire Forward, responded to the observations of the Lambert report and addressed the above issues by establishing the first of the two schemes described here, the Bioscience Yorkshire Enterprise Fellowship (BYEF) programme (2004-2006). BYEF was the forerunner to the current programme, the Yorkshire Enterprise Fellowship (YEF) scheme (2007-2010).

The Enterprise Fellowship format, such as BYEF and YEF, is an ideal way to address all of the above issues. There are already a number of excellent schemes that specifically promote business:university interactions, such as the Knowledge Transfer Partnerships (KTPs) and the EPSRC Industry Fellowship and CASE schemes. However, the role of the Enterprise Fellowship is to nurture enthusiastic academics along the commercial route by providing tailored training and mentoring, as well as advising as to the best route forward for commercialisation of their own ideas e.g. business start-up, licencing deal, proof of concept funding, industrial collaboration. In addition, the Enterprise Fellowship platform provides a modest budget as well as one-to-one mentoring to drive the commercialisation process, and in the case of the Scottish Enterprise/Royal Society of Edinburgh (RSE) and Biotechnology and Biological Sciences Research Council (BBSRC) Enterprise Fellowship schemes, a salary for 12 months.

We report here on the operation and outputs of the BYEF and YEF programmes and report experiences of participants.

3 Introduction to YEF

The Yorkshire Enterprise Fellowship (YEF) is a fully managed proof of concept support scheme designed to help university and National Health Service (NHS) Trust scientists create a business based on their research. The YEF scheme is fully supported by Yorkshire Forward, the Regional Development Agency for Yorkshire and the Humber, to a value of £2.3m, which supports 65 part-time 12-month Fellowships across the eligible disciplines of biosciences, chemicals and healthcare technologies. This includes 61 individuals selected from the nine universities in the Yorkshire and Humber region as well as 4 clinical researchers supported by Medipex, the innovation hub for Yorkshire and the Humber. YEF offers a unique package of support, including up to £10,000 direct support to progress the science or technology, specialist enterprise and personal development training, a personal business mentor, customised market research and assistance to find investors and signposting to other funding sources.

The current YEF scheme builds on the highly successful pilot BYEF programme (2004-2006), which resulted in 9 new spin-out companies from a cohort of 29 researchers and a return of over £4m in levered funds from an initial investment of £1.2m. The target output for YEF is the formation of 12 new ventures and acquisition of £3m of additional levered funds.

BYEF exceeded all expectations in the volume and quality of outputs that were achieved and we anticipate a similar success and return on investment from the current YEF programme. As of January 2010, 3 months before the current fellowship projects are due to end, the funding target (set by Yorkshire Forward) has been reached, three new companies have been registered and six fellows are generating turnover by trading from within their university. Around ten further spin-out companies are currently planned and talks are in progress regarding seven separate licencing deals or industrial collaborations.

4 Application Procedure (YEF)

Researchers accepted onto the YEF scheme had to demonstrate a real and sustained desire to develop compelling and world-class science, to understand market opportunities and how to exploit them. The Fellowships were open to applicants from all universities in the Yorkshire and Humber region (Bradford, Huddersfield, Hull, Leeds, Leeds Metropolitan, Sheffield, Sheffield Hallam, York and York St John). The application procedure comprised 3 key parts: initial assessment, formal refereed application and presentation to Admissions Panel.

4.1 Initial Assessment

Before submitting a formal application, potential applicants were encouraged to discuss their idea with the project managers to check that the scope fits within the technical area of the programme and that basic criteria are met. In order to ensure the components of the scheme were understood and that both the proposed science and the individual were likely to meet the standards required by the programme Admissions Panel, in some cases the programme manager arranged a face-to-face discussion with the applicant. This pre-screening is the starting point for a close working relationship, which is essential to the success of the project and the Fellow's experience of the programme. Suitable applicants were then invited to complete a short expression of interest form via a dedicated YEF website, which registered contact details and a 200 word summary of the business idea.

4.2 Formal Application

Following in-house assessment of the expression of interest, applicants were invited to submit a full application, with support from the scheme manager. A detailed technical assessment was carried out by specialist staff and several independent referees were consulted for their view on the validity and novelty of the idea proposed. Assuming satisfactory responses were obtained at this stage, the applicant was invited to present his idea to the YEF Admissions Panel.

4.3 Admissions Panel

The Panel comprised experts from industry and academia, operated according to full terms of reference and formal confidentiality agreements were in place. Applicants were invited to give a 15-minute presentation about their idea, followed by questions from the Panel. The presentation was to include an outline plan for their fellowship year indicating the current state-of-the-art together with project priorities, milestones and anticipated achievements. Criteria for acceptance onto the scheme was based on three elements, (i) the quality and novelty of the science, (ii) the proposed commercial exploitation and (iii) the commitment of the individual. Three decision options were open to the Panel; (a) acceptance onto the programme without changes; (b) application rejected (in which case the programme managers endeavored to signpost other options open to the application) or (c) referral for clarification on technical issues relating to the application (then either signed off by Chair's action or re-presented to Panel).

4.4 Fellowship Cohorts

The 65 Fellows accepted onto the 12-month scheme were divided into 4 cohorts, with staggered start dates over the programme duration. This facilitated operation of the group training programme and management team time requirements. Once individual projects were underway, a formal review process took place throughout the Fellowship year with meetings of the full project team every three months. These meetings were attended by a designated member of the management team and usually took place at the Fellow's host institution. To ensure engagement from the Fellow, (s)he was responsible for organising the meeting on the lines of a formal board meeting, together with preparing the agenda, papers and minutes. In the early stages, the management team helped with this process, as it was new to many Fellows. The approach worked very well and gave the Fellow real ownership of the project and an opportunity to develop a useful business skill.

5 Scheme Delivery

YEF comprised the following package of support:

- £10,000 direct support to develop the technical elements of the project;
- A specialist enterprise training and personal development programme delivered by experienced professional trainers (including business finance and accounting, IP management and leadership skills, see details below);

- A personal business mentor with specialist commercial expertise in the technical and commercial sector of interest;
- Specialist market research to help define the direction of the project and to help secure investment or further funding;
- Online project management facility;
- Assistance to find investors and signposting to other funding sources.

5.1 Enterprise Training and Personal Development Programme

A high-quality education programme has been essential to the Enterprise Fellowship schemes. In the pilot programme over 2500 training hours were delivered for the BYEF Fellows and under YEF over 4000 training hours in more than 50 events during the course of the programme were delivered. Expert trainers from a wide range of disciplines were engaged to deliver a modular training programme over the course a year for each cohort.

The Core Training Programme comprised:

- Introduction to the Enterprise Fellowship year; Project Planning; Technology Roadmapping;
- Delivering the evidence for a successful Proof of Concept Project;
- Intellectual Property;
- The Role of the Company Director;
- Building Effective Business Relationships;
- Financial Acumen for Directors;
- Leading a High Performance Team;
- Intellectual Property Clinic (one to one sessions with a patent attorney);
- Buying, Selling & Valuing Companies and Raising Finance;
- Future Planning, Putting it all into Context.

Tailored training materials supported all sessions and Fellows were introduced (via the project extranet, see below) to the wealth of business and enterprise support services available both in the local region and nationally.

Fellows also had the opportunity to attend the following specialist sessions, depending on their area of interest:

- Marketing Masterclass
- Design Workshop
- Selling to the NHS
- Medical Device Regulations

Towards the end of their Fellowship, all Fellows were required to take part in a mock investment presentation which we run along the lines of the popular television programme *Dragons' Den*. Fellows have just 5 minutes to present their investment idea before a panel of 4 investment experts. This is an ideal opportunity to practise the art of making an investment pitch in a safe environment and is welcomed by all participants as a very valuable experience.

5.2 Personal Business Mentor

Each Fellow was assigned a personal mentor at the outset of their YEF year. YEF mentors were paid directly by the scheme and operated under contract and confidentiality agreements. The right mentor is vital to the success of the project and we ensured that the best possible match between Fellow, topic and mentor was made from the outset. Before a contract was put in place, an informal meeting between the potential mentor and mentee was arranged to assess from both sides if they felt the relationship would work. The proposed commercial developments ranged from concept to early stage evaluation to prototype design and commercially ready products. Depending on the stage of development, the work could be to assess possible opportunities, help prepare a business plan or to take a project through to conclusion by formation of a spin out company, licensing deal or joint venture.

Knowledge transfer from academia to the marketplace is often complex and the Mentor was expected to help the Fellow to define the most suitable route of exploitation. Ideally, they should have had hands-on experience of start up and development of small businesses, together with up to date knowledge and contacts in the relevant discipline. As most Fellows were very new to the commercial world, it was essential that each Mentor possessed suitable coaching skills to assist the Fellow in his development. The Mentor needed to have a genuine interest in the project and the Fellow and was expected to offer advice and encouragement for the duration of the project on a formal and informal basis.

5.3 Online Project Management Facility (Extranet)

Each Fellow was given access to a dedicated online project management facility, which was used throughout the Fellowship year giving password-protected access to all members of the project team, including management staff, mentor and university representatives. Fellows were encouraged to post all project communications on this facility, which served as full repository of project documentation. The system was a very efficient and cost-effective tool to keep all Fellows and their supporters up to date on individual and team developments. Key elements included milestone planning, action lists and document tracking together with project reporting facilities.

Fellows also have continued access to a private part of the project website (www.yef.org.uk) detailing an extensive range of resources including an events calendar, over 100 business checklists including finance, legal and management topics and links to potential funding sources.

5.4 Assistance to Find Investors and Signposting to Other Funding Sources

A key aspect of the YEF programme is to encourage Fellows to develop their projects beyond the duration of the Fellowship year and to be knowledgeable about the options available for raising finance for a spin-out business. The specialist training modules on raising finance and working with different types of investors provide an introduction to this area but we also aim to directly link Fellows with regional, national and international investment and funding.

6 Independent Evaluation: Pilot BYEF Scheme

In Autumn 2005 the pilot BYEF programme was reviewed by independent consultants on behalf of Yorkshire Forward who interviewed various stakeholder groups linked to the scheme. Without exception, all viewed the programme very positively, recognising its value as a means of engaging with the region's academic knowledge base to develop commercialisation opportunities at an early stage. This extensive report highly commended the operation, delivery and outputs of the scheme. A few key comments from the report are reproduced below to illustrate the impact of the programme in the academic and business communities.

"BYEF is perceived to provide an important progression route for student bioscientists to develop their career beyond academic research. A number of stakeholders emphasised a lack of commercial awareness among graduates in the sector. They felt that the Fellowship has been extremely successful in tackling this issue and providing beneficiaries with the necessary skills set to recognise and realise the commercial potential of their research. The training received by Fellows in turn develops their confidence by increasing their knowledge and skills – all three vital attributes to set up and run a successful company."

"Supporting participants to adopt a more entrepreneurial and commercial focus in their careers was identified as one of the key benefits of the Fellowship. Participants indicated that their career focus prior to their involvement in the project had been strongly focused on research, rather than its commercial application."

7 The Fellowship Experience

Fellows in the pilot BYEF and current YEF programme all produced a detailed technical report at the end of their Fellowship year. In addition to the technical and commercial progress, Fellows also reported on their personal experience. The vast majority of participants have gained much more than commercial training from their Fellowship experience. The Fellowship has created a band of commercially astute and business-aware professional researchers who directly and by influence will contribute greatly to the future growth of the region's universities. Whilst researchers engage at a wide range of levels, all report a very positive experience. Selected comments from both BYEF and YEF Fellows are reported below.

"*As a researcher based in a University environment, I have never had a formal exposure to any form of training in business skills. The various workshops I attended covered a number of subjects related to running a biotech business including technical, legal, and financial and management. All these workshops were* *extremely well organised and hugely informative. The fellowship also provided me with various networking opportunities. Since becoming a BYEF fellow I have had various opportunity to interact with other fellows, business angels and leaders in biotech industry. This has been an extremely valuable experience."*

"When I started I had a good idea and I knew what I wanted to do, but had little idea of how to do it, or of what it would entail. At the end of one year I now know that there is much that I don't know! I have learned an enormous amount during my BYEF year and benefited greatly from the fellowship."

"I have found the scheme to be a hugely positive, confidence-boosting and motivating experience. The benefits of a support network comprising the skills and advice of my mentors, the management team and the resources to progress the commercial aspect of the technology cannot be overstated. The whole process has gained considerable momentum over the course of the Fellowship and it is unlikely that we would be considering imminent spin-out had the scheme been unavailable."

8 Conclusions

The role of Enterprise Fellowships is to bridge the gap between a traditional academic research grant and a Proof of Commercial Concept (PoCC) scheme, arming the PoCC applicants with relevant training to increase their chance of a successful commercial venture.

Within the Enterprise Fellowship structure, there is recognition for the fact that not all projects are suitable for company start-ups. Indeed negotiation of licencing deals and R&D collaborations are often the best way forward, which are both valuable ways of bringing wealth to the local economy. The personal mentors possess relevant skills and experience to advise on these matters. An independent interim review of a similar scheme, the Scottish Enterprise/RSE Enterprise Fellowship, highlighted the individual mentor input as being of high importance to the entrepreneurs as well as the importance of sharing experiences with other Fellows enrolled on the scheme [5]. The report also demonstrated an impact on confidence and attitudes amongst the fellows and reported the scheme as a cost-effective way of generating new business and creating high quality jobs. This is of extreme importance in demonstrating that public money is well-spent in the science and technology industries. A later review of the same scheme reported other intangible benefits of the programme including the retention of entrepreneurs and intellectual property in the local area [6].

Potential future directions of YEF include expansion in to other industry sectors and geographical areas, as well as provision of a formal qualification, e.g. MSc. Whilst expansion to other sectors would enable support to reach a larger number of people, some of the targeted elements of the training may be harder to coordinate under a single scheme and it would not be feasible for the skills of the management team to cover the range of industries as they do at present under YEF. However, having a mixture of Fellows from different backgrounds could help with future investment pitches as early on they would need to be able to describe their product to non-specialists.

The idea of a formal qualification is a popular one as it would be useful for future employment to demonstrate business knowledge, even if the Fellowship does not result in a new start-up company. One example of this is the London South Bank University (LSBU) Enterprise Associate Scheme, which is open to final year LSBU undergraduates or alumni only [7]. Under their scheme, MSc students are given a two-year bursary, office space in an entrepreneurial environment and training as well as access to business and technical experts and mentors, and this scheme has proved very successful.

A hurdle for many of the YEF projects was in IP filing, since the universities have a limited budget for this. The costs of IP filing were not eligible under YEF, but it is worth considering a budget for this in future schemes. In addition, in order to make the Fellowship schemes self-funding, it is also worth considering taking an equity share in any companies formed, with any funds being put into future rounds of the scheme.

From the independent and Fellow's assessments detailed above, it is clear that these schemes fill a clearly identifiable gap in significantly enhancing the commercialisation of university research as a means to enhance UK productivity and economic growth. The methodology developed under YEF is an example of best practice that would be readily transferable to other disciplines and regions.

References

1. Lambert, R.: Lambert Review of Business-University Collaboration. HMSO, London (2003)
2. Kitson, M., Howells, J., Braham, R., Westlake, S.: The Connected University, Driving Recovery and Growth in the UK Economy. NESTA (2009)
3. Office for Life Sciences, Life Sciences Blueprint, HM Government (2009)
4. Yorkshire Forward, The Regional Economic Strategy for Yorkshire and Humber 2006-2015 Progress Update (2007)
5. SQW Ltd., Enterprise Fellowships - Interim Review and Evaluation; Summary Report to Scottish Enterprise (2001)
6. Ernst & Young LLP, Oxford Economics, Review of the Scottish Enterprise and Royal Society of Edinburgh Enterprise Fellowship Programme (2007)
7. Grace, S., Tinley, E.: The LSBU Enterprise Associate Scheme – an Enterprising Approach to Entrepreneurship. In: Innovation Through Knowledge Transfer 2009, Conference Abstract (2009)

Abbreviations

BYEF	Bioscience Yorkshire Enterprise Fellowship
LSBU	London South Bank University
RDA	Regional Development Agency
RSE	Royal Society of Edinburgh
YEF	Yorkshire Enterprise Fellowship

Centre for Innovation and Technology Exploitation (CITE)

Tony Allen

Nottingham Trent University
e-mail: tony.allen@ntu.ac.uk

Abstract. The Centre for Innovation & Technology Exploitation (CITE) is an innovative technology transfer unit that has been jointly established at the Nottingham Trent University (NTU) with the aid of funding from NTU, the East Midlands Regional Development Agency (*emda*) and the European Regional Development Fund (ERDF). Using a unique innovation ladder of support, the CITE has successfully engaged with several small-to-medium enterprises (SMEs) throughout the East Midlands region with a view to facilitating the transfer of Intelligent Systems research knowledge from academics in the School of Computing & Technology at NTU to the participating SMEs.

1 Introduction and Context

The East Midlands is a region that is rich in respect of the international reputation its Universities have for innovative science & technology research but relatively poor in terms of being able to empower the region's underlying enterprise base exploit this research for the benefit of the regional economy. The regional development agency (RDA) responsible for economic development in the East Midlands region (*emda*) explicitly highlights this fact in its regional economic strategy (RES)[1] report and both it and the region's major Universities have recently made great efforts to address this shortcoming. The Centre for Innovation & Technology Exploitation is one expression of NTU's commitment to that strategy[2].

The CITE is an ICT-based technology transfer unit that aims to facilitate interaction between higher education, business and industry in order to encourage and stimulate business innovation and creation. Embedded within the School of Computing and Technology at NTU, the centre is intended to serve companies and individuals who are seeking access to expert advice & leading-edge research in the area of ICT technologies and its associated practices.

Exploitation of technology-based innovation is an uncertain (and therefore risky) business. In general, SME's do not have the time, the spare capacity or the

[1] Emda regional economic strategy: http://www.emda.org.uk/res/
[2] BioCity and the Hive are two other example of collaborative innovation support units jointly funded by NTU and *emda*.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 249–256.
springerlink.com

financial resources necessary to fund this risk. By effectively using the CITE as their Research & Development arm, participating SMEs are able to build, test and evaluate prototype versions of innovative products using state-of-the-art ICT technology. Having thus minimised the risks involved with introduction of new technology, SMEs are then more prepared to engage in collaborative project development leading to generation of shared income, royalty and IPR.

What follows in the rest of this paper is a concise history of the conception, creation and early years operation of the CITE. The paper concludes with a personal reflection on lessons learnt during this four year process, acknowledgement of contributions made to this process by the authors colleagues and a signposting of future directions for the CITE.

2 CITE Conception and Centre Creation

The CITE concept was independently conceived by the author as part of his 2004/5 Medici Fellowship activities. That innovative, Midlands based, technology-transfer training programme was designed to create champions of academic enterprise amongst selected members of the region's academics in order to embed entrepreneurial expertise within the Midland HE institutions participating in the scheme. One direct output from the author's fellowship was a plan to develop a commercial level VoiceXML (vxml) host facility at NTU that could be used to allow the region's SMEs the opportunity to explore how to exploit this state-of-the-art speech-enabled systems technology for their commercial advantage.

During 2006, further work with NTU's Business, Innovation and Creation unit (BIC) developed this initial concept into a broader plan for the development of a Centre for Innovation & Technology Exploitation that would develop state-of-the-art ICT demonstrator systems that could be used to showcase the full range of Intelligent Systems research being undertaken by the academics within the School of Computing & Technology at NTU. The idea being to use these demonstrators to encourage interactions between the academics and interested SME's in order to facilitate knowledge transfer between NTU and the region's business base.

A draft proposal describing the CITE and its intended remit was informally presented to the RDA to ascertain whether it would consider jointly funding the development of such a centre. To add support for this proposal, pilot funding from a sub-regional agency (Greater Nottingham Partnership[3]) was obtained to organise a one-day LabSpace event as part of the inaugural (2006) Game City[4] festival in Nottingham. Eight technology demonstrators (four from NTU and four from the University of Nottingham) were duly assembled and presented for public viewing in a gallery in the centre of Nottingham. This event, and the wider Game City festival within which it was embedded, were both seen as being successful demonstrations of their respective concepts and an invitation to submit a full funding proposal for the CITE ensued.

[3] Greater Nottingham Partnership: http://www.gnpartnership.org.uk/
[4] Game City: http://gamecity.org/

In Feb 2007, almost two years after the original concept was conceived, an initial 2-year funding grant for the CITE was successfully awarded and two full-time research fellows were employed to develop the technology demonstrators to be used to showcase the CITE and to facilitate any subsequent technology transfer activity between the NTU academics and SME community.

3 Demonstrator production

Six advanced technology demonstrators have since been successfully created and video vignettes, showing them in operation, have been linked into the facilities page of the CITE's website http://www.ntu.ac.uk/facilities.

The six technologies showcased are:

- Speech-enabled Nottingham tram information system
- Biometric computer network logon system
- Geographical information system (shown above)
- People monitoring using thermal imaging
- Wireless robotics
- Wiimote virtual cane

It is worth noting at this point that the function of these demonstrators is not to present a ready made innovative solution suitable for immediate commercial exploitation (although that is a possibility) but rather to present a technology in context to the interested business viewer in the expectation that the viewer would then be able to identify a potential technology solution to a business opportunity/problem unique to their company. Subsequent interaction between the CITE team and the interested business would then, hopefully, lead to the development of a bespoke technology prototype or software solution that the company could then evaluate/commercialise.

It may also be interesting to note that the CITE demonstrator systems, as well as being used to encourage technology transfer activity, are also regularly used as part of the open-day activity arranged for prospective undergraduates to the School of Computing & Technology. It is unclear how much influence demonstration of these systems to prospective students has on their final choice of University but their inclusion in the open-day programme of activities certainly does help make the case for NTU being a University with a close symbiosis with industry.

4 CITE Showcasing

In order to present the CITE to as large a business audience as possible, the CITE team regularly lead on a number of business showcase events held at the centre. Some of these showcase events are jointly organised by the CITE and Business Link[5] or by the CITE and Derbys. & Notts. Chamber of Commerce[6]. The involvement of these two business support organisations is intended to ensure that the programme of technology update events is timely and relevant to the business community. Business Link & the Chambers of Commerce are well positioned to gather information on the nature and trend of demand from SMEs and their direction and feedback is considered key in the CITE's knowledge transfer awareness raising activity planning. Both organisations also publicise the CITE technology showcase events to their respective SME audience.

A variety of event formats have been trialed over the lifetime of the CITE project but the one that appears to fit best with the target audience are breakfast events. These tend to start at 0730 and finish by 0930; giving the delegate an opportunity to view the presentation and still get to work in time for a full day's operation. Other feedback from these general knowledge transfer awareness raising activities indicates that businesses like to hear directly from other businesses about their experience of undertaking knowledge transfer activities with a large HE institution.

In addition, to the organised events described above, other more informal one-to-one contacts are also used to convert an initial enquiry or referral into a business intervention. Typically, these involve a more directed presentation of the CITE activities where the demonstrations shown are specifically targeted towards the sort of technology products/services the company delivers. Such targeted one-to-one introductions are found to be more readily convertible into a full-blown business intervention than more general showcasing introductions.

5 Innovation Ladder of Support

Once contact with an SME has been initiated, the CITE team have a range of innovation support mechanisms available that allow the engagement to proceed from the primary (two day) intervention up via a medium scale (100hours) Stimulating

---

[5] Business Link: http://www.businesslink.gov.uk/eastmids
[6] Derbys. & Notts. Chamber of Commerce: http://www.dncc.co.uk/

Innovation for Success (SIS) interaction to the more traditional (2 year) Knowledge Transfer Project (KTP) level. This innovation ladder of support is unique to NTU & the CITE.

The CITE funding award(s) effectively sponsors the primary interventions so these are 'free at the point of use' to the company. The SIS interactions are another, separately funded, technology transfer mechanism where the company is expected to partly-match fund the project with £500 of their own money. These were pioneered by the BIC team at NTU before the creation of the CITE and are used to facilitate technology transfer interactions between SMEs and academics throughout the University as well as being used as part of the CITE provision. The longer-term KTP programmes are match funded by the company and the BERR[7] to enable a two-year in-company graduate placement to be undertaken with academic supervision for a specific technology transfer activity.

The examples below illustrate how these mechanisms have been used to provide real-world interventions at the CITE - although the specific details of the interactions have been omitted for reasons of commercial sensitivity.

- Primary intervention – a small local R&D based company approached the CITE with a commercial need to explore how well trackside infrastructure could be identified from suitably augmented video footage obtained during the course of a train journey. The CITE team produced a working software prototype to demonstrate proof-of-concept which the company then intended to use as part of a tender for contract presentation.
- Simulating innovation for success (SIS) interaction - a university spin-out company engaged with the CITE team in the production of an arboriculture software package that could be used by the company's franchisees to analyse thermal images of trees.
- Knowledge transfer project (KTP) - an established medium sized enterprise is currently undertaking a KTP with an academic from the School of Computing & Technology at NTU to develop a Semantic Web based version of an existing database search engine for commercial release.

The above examples are illustrative of the range of interactions that have taken place at the CITE but they do not, necessarily, demonstrate how the individual innovation support systems are linked together to make a coherent innovation ladder of support. However, the last example is, in actuality, the culmination of a series of interactions that started with a primary intervention level contact between a University graduate employed in a local company and one of his ex-lecturers at NTU. This then led on into a SIS interaction where another NTU postgraduate was employed part-time to undertake prototype development work. The resultant ongoing KTP described above - with the NTU PhD graduate now being employed by the company as the KTP associate – is the final outcome of this technology transfer process.

[7] KTP programme website: http://www.ktponline.org

6 Academic Enterprise Role Model

As well as being the project manager for the CITE project, the author remains a practising academic with a teaching load and ongoing research interests. This dual academic/technology transfer role does have its disadvantages when it comes to day-to-day management of the CITE but it has enabled the author to become an effective academic enterprise champion to which other academics in the School of Computing & Technology at NTU are able to refer when considering initiating technology transfer activity.

As exemplification of this role, the author and one of the CITE research fellows have successfully undertaken the following activities leading to the commercialisation of their collective speech-enabled system research:

- Successfully apply for Innovation Fellowship[8] funding to develop a proof-of-concept demonstrator of a novel local biometric identify management system.
- Work with the college business development manager to file a UK patent for the novel voice verification solution.
- Made use of the *emda* business champion programme to obtain advice on developing a business case for commercialisation of the product once developed.
- Use the filed patent and developed prototype to successfully obtain a pathfinder award from the Lachesis Venture Capital[9] fund to undertake a freedom to operate search and market analysis for the system in question.

Further work leading to the creation of a spin-out company and the licensing of the developed technology to interested corporate institutions will be undertaken during the course of 2009.

The dual academic/technology transfer unit project management role also has benefits for the teaching provision within the School of Computing & Technology. For example, the commercial level vxml demonstrator system, developed at the CITE, has been successfully integrated into the teaching & assessment schedule of the BSc final year Pervasive Computing module. As a result, NTU computing graduates now have an opportunity to include practical vxml development as part of the programming portfolio of skills. Further integration of technology transfer activity demonstrator outputs into the teaching provision of the school is envisaged over the coming year with Bluetooth and Iphone development at the top of the agenda.

7 ERDF Continuation Funding

By the summer 2008 it was clear that the CITE would be able to deliver the expected outputs of its original funding grant and that it's continued operation would meet the future strategic objectives of both the University and the RDA. Consequently, it was decided that a proposal for ERDF funding should be produced. The objectives for this continuation funding were as follows:

[8] Innovation Fellowship: http://www.nottingham.ac.uk/fellowships
[9] Lachesis VC fund: http://www.lboro.ac.uk/business/portfolio/lachesis.html

- Allow the CITE to continue its programme of providing businesses, particularly science and technology SMEs identified for growth by the RES - including healthcare, transport and environmental sectors - with access to digital enabling technologies and graduate placement opportunities to support innovation and the uptake of new technology products and processes.
- Enable the CITE to increase its HEI/SME knowledge transfer activity to the point of self-sustainability through the establishment of revenue-sharing agreements with regional companies. The aim being to generate sufficient annual income for the CITE to become a self-sustaining regional centre of excellence for technology transfer.
- Provide the CITE with an opportunity to integrate itself within the East Midlands simplified business support network. In particular, a programme of technology awareness raising events will be jointly organised with the Derbys. & Notts. Chamber of Commerce with a view to directly addressing the technology transfer needs of their 6000+ members and affiliates.

Despite a rather protracted nine month consultation process, a substantial 3-year ERDF grant for continuation of the CITE activities was successfully obtained in Feb 2009. Unfortunately, the uncertainty in funding being awarded did contribute to the departure of one of the original CITE research fellows but the vacated position has been recently filled with the appointment of two 50% part-time research associates. In actual fact, by employing two part-time associates rather than one full-time associate the CITE has been able to increase its range of available technology expertise without increasing its funding requirements. As both of the part-time research associates are also happy with their respective part-time positions this is seen to be an example of one of those elusive but nonetheless real win-win situations.

8 Lessons Learnt

To conclude, the author's personal reflections on the lessons learnt, during the last four years of technology transfer activity, can be summarised as follows:

- Innovation without exploitation is an opportunity lost. This fact is, perhaps, particularly most apt in the current post credit crunch environment where innovative businesses are being championed as the leaders of any economic recovery process.
- Innovation is a costly and risky business. As such many SMEs have difficulty finding the time, money and technical expertise necessary to invest in the research & development needed to bring innovative products to market. Providing a publicly available R&D facility that can help minimise this risk can make a useful contribution to a regional economy.
- Technology transfer is a valuable, if somewhat undervalued, activity that can make a difference to forward thinking SMEs in a regional economy. The problem is one of convincing the academic and business communities that the

funding of such activity is a better way of regenerating the economy than just funding research or reducing business taxes.

- Obtaining the political support and funding to create and operate a technology transfer unit is a lengthy and somewhat bureaucratic process. Perseverance is a necessary pre-requisite in a technology transfer unit manager!

9 Future Directions

A forward strategy for the CITE was built in as one of the principle aims of the ERDF funding application. The CITE aims eventually to achieve self-sufficiency. By generating sufficient income-steams from the revenue-sharing agreements, that are part of the centre's objectives, the CITE aims to be able to maintain its innovative knowledge transfer activity post ERDF funding.

Once established as a self-sustaining regional centre of excellence for ICT innovation and technology exploitation, it is anticipated that further business interest will be self-generating by way of business-to-business (B2B) recommendations and case study publicity. It is also anticipated that attaining a regional centre of excellence reputation will facilitate the CITE's entry into collaborative ventures with other leading Universities in the East Midlands that will lead to other funding opportunities.

In terms of extending the CITE beyond its current ICT-based technology transfer remit, it would be interesting to see if the same technology transfer model could be translated over into the physical and biomedical sciences. Establishing an Institute of Innovation & Exploitation that is able to provide an innovation ladder of support for Science & Technology SMEs is seen by some in the NTU senior management as the next major development for the CITE. As a first step towards this, the CITE is seeking a closer working relationship with the Thin Film Services facility[10] at NTU.

Acknowledgments. In producing this paper, the author would obviously like to acknowledge the East Midlands Regional development agency (*emda*) and the European Regional Development Fund (ERDF) for their respective funding grants – without which the CITE project would not have been possible.

The author would also like to acknowledge the contributions of the following NTU colleagues for their support during the creation, development and ongoing development of the CITE: Prof. Yvonne Barnett (Pro Vice-Chancellor with responsibility for academic enterprise), Prof. Nasser Sherkat (Associate Dean of School of Science & Technology), Mr. Gwent Paylor (College of Science Business Development Manager) and Mr Sergio Grau (CITE research fellow).

[10] TFS website: http://www.ntu.ac.uk/sat/business/centres/thin_film_services.html

Knowledge Transfer and the National Physical Laboratory, UK

Phil Cooper, Tim Jones, Francis Tuffy, and Stuart Windsor

Knowledge Services Division, The National Physical Laboratory, Teddington, UK

Abstract. This paper describes the National Physical Laboratory's distinctive position and role in the field of knowledge transfer. It reviews the literature on definitions of knowledge transfer and looks at work that has already been done in the area of knowledge transfer in US national laboratories. It describes the drivers for knowledge transfer at the National Physical Laboratory (NPL) - one of the UK's national laboratories – using a new framework for knowledge transfer activities. Finally it presents evidential case studies of successful knowledge transfer at NPL, chosen and contextualized by consideration to this framework.

1 Introduction

> *"For the UK economy to succeed in generating growth through productivity and employment in the coming decade, it must invest more strongly… in the knowledge base, and translate this knowledge more effectively into business and public service innovation".* (HM Treasury Science & innovation Investment Framework 2004-2014)

The level of funding dedicated to assisting with this translation of knowledge from public sector investment in research to industry has increased substantially over the past decade in the UK. As noted in Lord Sainsbury's report 'Race to the Top' in 2007, this investment has resulted in a rapid increase in the amount of knowledge transfer from British universities to industry (HMT 2007, p55).

However, there are widely different definitions of the term 'knowledge transfer', and a tendency in public policy and the academic literature to focus on knowledge transfer between university research and industry, rather than considering other types of organisations that also generate knowledge and see knowledge transfer as a fundamental part of its mission, such as nationally funded government laboratories.

This paper describes NPL's role in knowledge transfer by reviewing the literature on definitions of knowledge transfer and looking at work that has already been done in the area of knowledge transfer in US national laboratories to set the background for discussion. It then describes the drivers for knowledge transfer at the National Physical Laboratory (NPL) - one of the UK's national laboratories – and uses a new contextual framework for understanding and managing the range

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 257–267.
springerlink.com

of knowledge transfer activities that are provided in response to those complex drivers. Finally, example case studies of successful knowledge transfer at NPL are presented, which have been chosen and contextualized by consideration of this framework.

2 Definitions of Knowledge Transfer

The words 'Knowledge Transfer' have a wide range of meanings and uses and encompass many different disciplines.

A recent analysis of the knowledge transfer literature (Graham 2008) identified three main academic subject areas where the term knowledge transfer is used widely: business & management, health & medicine and governance & policy. Each area has its own subdivisions, which Graham identified as follows:

Table 1 Adapted from Graham (2008)

Subject	**Areas where the term 'knowledge transfer' is used**
Business & Management	• Consulting/Consultancy • Organizational Culture • Organizational Learning • Knowledge Management • University-Business Linkages • Immigration and Industry
Health & Medicine	• Research Use in Nursing • Health policy making • Evidence-based movement • Clinical applications • Building knowledge based health organizations
Governance & Policy	• Implementation Units • Policy Transfer • KT in Education Policy • Technology Transfer and Public Policy

Within these areas, knowledge transfer has a very wide range of meanings and uses and overlaps with the terms such as: technology transfer, knowledge management, knowledge exchange, knowledge utilisation, research utilisation and research transfer. Confusingly, these terms can be used interchangeably, which makes working out exact definitions difficult. The main terms, and their definitions are described below.

'Technology transfer' is defined according to the discipline of the research, but also according to the purpose of the research (Bozeman 2000). Some researchers use the terms 'technology transfer' and 'knowledge transfer' interchangeably (Gopalakrishnan and Santoro 2004). Roessner (Roessner 2000) describes technology transfer as "the movement of know-how, technical knowledge, or technology from one organisational setting to another". However, technology transfer is now generally understood to be a much narrower construct than knowledge transfer: "'Technology' refers more to new tools, methodologies, processes and products. 'Knowledge', on the other hand, embodies broader learning evidenced as changes in the strategic thinking, culture and problem solving techniques used by a firm" (Gopalakrishnan and Santoro 2004).

Within the field of health, knowledge transfer has three levels of analysis: 1) clinical level wherein new knowledge is applied to improve the lives of patients; 2) managerial and policy strategies wherein decision making processes take place and; 3) educational level ensuring new medical professionals are learning evidence based techniques and understanding how to improve their application of knowledge over a lifetime (Graham 2008).

In Backer, David and Saucy's 1995 paper "Reviewing the Behavioural Science Knowledge Base on Technology Transfer", TT is defined as bridging the gap between knowledge and practice by going beyond the usual techniques (education, training, and dissemination of information) and engaging in "a *human process* which, if successful, leads to *individual and organisational change*".

'Knowledge utilisation' represents a terminology with the most significant academic history (Graham 2008). This started in 1979 with the publication of the journal *Knowledge: Creation, Diffusion, Utilization* (now called *Science Communication*). Knowledge utilisation research has largely addressed communication issues and research methods (Graham 2008).

Knowledge management is a field of study in which much effort and resources are devoted to the storage, sharing and transfer of knowledge via technology and social processes (Graham 2008). The various ways in which the social component of Knowledge Management has been approached is summarised by Graham as including: tacit knowledge/codification, the concept of "Ba", communities of practice, epistemic culture/ community, learning organization and absorptive capacity.

Liyanage et al identify that the field of Knowledge Management has branches that range from knowledge creation, through to knowledge capture, sharing, transfer, application, organizational learning and innovation (Liyanage et al, 2009). They argue that perhaps knowledge transfer can be understood and managed by a process model based on theories and definitions relating to knowledge communication and knowledge translation.

An alternative, unifying description of knowledge production, which is frequently cited and therefore worth mentioning, is 'Mode 2 knowledge production', characterised by "closer interaction between scientific, technological and industrial modes of knowledge production [and] by the weakening of disciplinary and institutional boundaries... " (Gibbons 1994).

Definitions have an importance beyond the semantics of language. The advent of concepts such as the knowledge based economy and knowledge workers have led to a focus on the knowledge based view of organizations, which considers the knowledge assets that may produce sustainable competitive advantage (Alavi and Leidnef, 2001). Clear and agreed definitions are required to develop academic thinking on what is good (and bad) knowledge transfer, alongside practical implementation of effective management processes to maximize the benefits of these valuable assets.

There is no single, accepted and clear definition of the term 'knowledge transfer'. It is used in a range of different professional spheres, from business and management, to higher education, to the health services and means something different in each. Fundamentally knowledge transfer is concerned with the movement of knowledge across boundaries created by specialist knowledge domains (Carlile & Rebentisch, 2003) and making a difference to outcomes and it involves interactions between people. What is clear, as observed by Liyanage et al is that knowledge transfer is not easy to understand or practice, especially due to the lack of clear-cut definitions.

However, looking beyond definitions, it is clear that NPL carries out 'Knowledge Transfer' type activity that cuts across traditional boundaries (e.g. science, communication, intellectual property exploitation). There is undoubtedly value in defining what we mean by knowledge transfer in the context of a nationally funded laboratory – the National Physical Laboratory – and understanding and defining what makes NPL distinctive.

3 Government Laboratories Knowledge Transfer in Context

The triple helix model (Etzkowitz 2007, 2008) presents a powerful framework for considering university-government-industry interactions, yet university-based or industry-based knowledge transfer dominates much of the literature on knowledge transfer. The government perspective is often focused on policy development issues and there is a scarcity of literature concerned with knowledge transfer carried out by other types of organisations in the UK, such as Research and Technology Organisations (RTOs) or publicly funded research establishments (PSREs). This section looks briefly at some work done on knowledge transfer at US government laboratories.

Crow and Bozeman (2000) provide data contrasting US university and government laboratories work in this area and find that the differences between university and government laboratories are difference of degree only. In a study of more than 1,200 university, industry and government laboratories, they found that 40% of university laboratories were involved in 'technology transfer' compared to 52% of government laboratories. Universities devoted 44% of their activity to publishing scientific papers, compared to 36% in government laboratories. They note the most vital difference between universities and government laboratories is students. They found that in surveying basic research projects, the results for government laboratories and universities were remarkably similar, except for the value added of students: "students are a means of technology transfer… and they often provide enduring links as the social glue holding together many faculty scientists and the companies they work with".

4 NPL in Context

NPL is one of the four laboratories within the UK, which together deliver what is known as the National Measurement System (NMS). The NMS is essentially a collection of measurement related facilities, capabilities, and skills which ensures effective trade and competitiveness, underpins standards and regulations, facilitates innovation, and underpins quality of life and environmental protection.

NPL has been delivering this role within the UK for more than a century, and sits at a unique intersection between government, industry and the UK science base. NPL is also unique within the UK national laboratory arena as one of only two GOCO (Government Owned, Contractor Operated) national science assets. The contractorisation business model introduced in 1995 provided an opportunity to tie the delivery of shareholder value to the parent company (Serco) with demonstrable and increasing economic and social impact within the UK.

The Vision of the laboratory, as the National Science and Technology Laboratory for Business and Innovation is:

"To deliver the highest economic and social impact as a world leading National Measurement Institute through excellent, responsive science and knowledge services".

NPL realises this by demonstrably achieving:

- Excellence in science
- Increased exploitation of that science to boost UK competitiveness and quality of life
- Integrity and independence as a national asset
- Enhanced international standing

It can only do this with the effective transfer and exchange of knowledge from validated sources with the appropriate stakeholders.

Therefore NPL is distinctively differentiated by virtue of being tasked to perform the roles of both a Research & Technology Organisation (RTO) *and* a Public Sector Research Establishment (PSRE):

- Like an RTO, part of its role requires it to primarily provide a commercial return on investment.
- Like a PSRE, it also is required to provide wider socio-economic returns on public investment.
- Co-funding from commercially focused sources also joins this public investment, adding an additional layer of complexity to decisions based on ROI.

5 Comparison with Shareholder vs. Stakeholder Debate

Understanding the significance of potential issues arising from this conundrum of duality of purpose can perhaps be better understood by considering the long running shareholder vs stakeholder debate. This is relevant as it involves similar arguments pertaining to both financial and social benefits. The prima facie tensions that exist between shareholders' demands for return on capital (Sloane, 1967) and maximum value (Friedman, 1962) and the more recent stakeholder approach to corporate activity (Evans and Freeman, 1994 and Proust et al. 2002) offer an interesting perspective into the purpose of knowledge transfer at NPL.

The laboratory has a set of shareholders who, quite legitimately, require a profitable return from providing their resources and time to maintain the level of investment needed to ensure science excellence. The wider stakeholder community (including government, other customers, employees, and UK businesses) seeks impacts that include societal as well as economic outcomes. The situation is complicated still further by the nature of economic impact from knowledge transfer activities that might result in both personal gain (for an entrepreneur for instance) and wealth creation across a whole industrial sector.

In addition to any *corporate social responsibility* (Smith, 2003) to do public good the laboratory has a national mission to support economic development through supporting UK businesses. So, rather than an apparent dichotomy between choosing between perspectives mirrored in the shareholder and stakeholder interests dilemma, there is a constructive tension that has helped form the laboratory's view of knowledge transfer impacts across a wide spectrum stretching from dissemination to exploitation of knowledge.

6 Knowledge Transfer at NPL

NPL is required by its principal funder - the Department of Business, Innovation and Skills - to transfer knowledge generated through public sector investment in science for the benefit of society. NPL is engaged in a wide range of activity that can be classified as knowledge transfer, from activity that is carried out to principally change behavior, to activity that is principally about commercial exploitation of IP (IPX). The continuum can be described as follows:

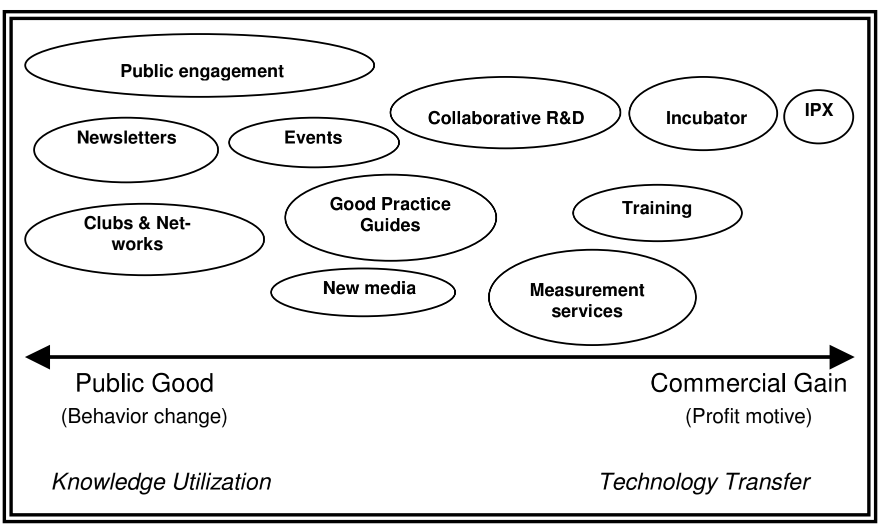


Fig. 1 Knowledge transfer continuum at NPL

At the left hand end of the scale the activities have been labeled as 'pubic good', i.e. where there is no direct commercial gain from carrying out knowledge transfer activities. NPL is tasked as part of its remit as a national laboratory to communicate its science and to engage with business and the community. At the right-hand end of the scale the activities are classified 'commercial gain', i.e. activity that is carried out for a cost recovery or profit motive as the principal driver. This continuum is clearly extremely wide-ranging and covers activity from across the spectrum of definitions of knowledge transfer, from knowledge utilization, or science communication, on the left-hand end of the scale, to technology transfer on the other.

There have been many studies of the impact derived from both NPL and the National Measurement System (a £60 million government funded programme), which it delivers for Government, which illustrate the wide socio-economic return on the investment made. For instance, the 1999 review of the National Measurement System (PA Consulting 1999) concluded:

"We find that measurement in the UK as a whole delivers significant positive impact into the economy of 0.8% of GDP. This equates to £5 billion per annum in terms of Total Factor Productivity. This is a large number, most of which is either directly or indirectly underpinned and enabled by the NMS. The delivery of this level of economic impact by a £38 million annual programme is, we believe, exceptionally large and positive for a Government technology investment."

A further study completed in 2005 (National Measurement System Impact Assessment), which reviewed the direct economic impact of companies engaged with NPL and the NMS further concluded:

> *"… the NMS supports the development of new products through better measurement, enabling users to achieve annual increased profits of £712 million."*

While macroeconomic modeling, and industry wide surveys are useful in establishing the return of investment of the National Measurement System, the role of Knowledge Transfer in delivering this impact is often lost. NPL routinely develops case studies for the programmes that it delivered, which demonstrate the range of economic as well as social impacts that NMS interventions achieve. A few of these case studies are presented below.

7 Case Study 1: Measurement for Innovators

From the "Support for Innovation" section of the knowledge transfer continuum, NPL delivers a wide range of programmes that allow UK companies overcome technical barriers to improving their processes and producing new and improved products. An example is Measurement for Innovators, which targets technical know-how from the National Measurement System laboratories[1] at high growth-potential companies to enable them to overcome technical barriers to innovation.

---

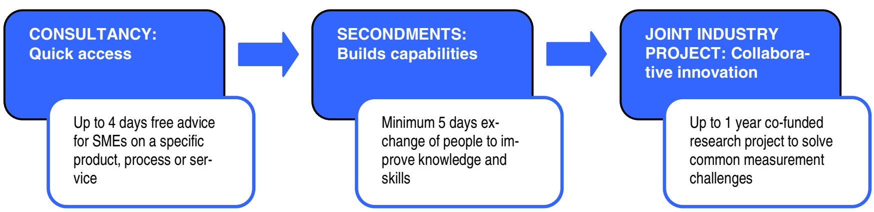
[1] National Physical Laboratory (NPL), LGC, TUV NEL, and the National Measurement Office (NMO).

To date, more than 400 companies have benefited from the scheme – of which the first 200 reported £10 million in increased sales and profits. The companies achieved this through innovation in their products, services and processes and Measurement for Innovators helps by:

1. Providing information that is key to companies making the right business decision:
"Without this support we could have spent up to £100,000 to modify the system and if we had pursued the development of the product we could have done enough damage to sink the company." Nigel Rees, GSD Navigations
2. Reducing development time to market:
"The support we have received has been invaluable and will enable us to produce state-of the-art products with a much faster time to market." Victor Higgs, Applied Nanodetectors.
3. Building critical capabilities:
"Without this project, there wouldn't be a business." Peter Plasman, Photometrics

The programme provides quick and easy access to measurement experts and facilities through consultancies; then builds capabilities in the business through secondments and, where appropriate, catalyses collaborative innovation through Joint Industry Projects.

The schematic below gives more detail to the workings of the 3-phase delivery structure.



The programme has been running since 2004 and in that time it has delivered:

- ***327*** (or more than ***1,000 days*** of) consultancies.
- ***186*** (or more than ***400 weeks*** of) secondments.
- ***69*** Joint Industry Projects – attracting more than ***£3.5million*** of industry funding.

8 Case Study 2: MTDATA

An example from NPL that demonstrates a move from knowledge generation, across the knowledge transfer continuum to reach exploitation as a commercial offering is MTDATA. This is an easy-to-use thermochemical optimisation software/data package that offers process efficiency savings to the chemicals and materials sectors.

The industrial problem that MTDATA addresses is to characterise and model the complex interactions amongst a range of different materials with different properties. The theory, reference data and analysis that sits behind MTDATA was developed across a range of science teams working on different programmes under the National Measurement System.

As the programme developed it became apparent that to gain maximum impact from the dissemination strategy a software package should be developed that could run on a standard desktop. Further, that the package could be tailored to the needs of specific industrial sub-sectors and its costs recouped by commercial licensing and technical support services to individual businesses that would gain competitive advantage from its use.

The uptake of the package has been global but mostly in research departments of UK Universities and large technology-rich global enterprises with large UK footprint. It has found particular success in helping to solve chemical thermodynamics problems in manufacturing, corrosion, product design and environmental impact.

Having a commercial offering has the advantage of allowing access to demonstrable impact from both qualitative and quantitative sources. Survey feedback from users indicates benefits including better product design, process improvements and cost savings. And economic data demonstrates the product's financial sustainability as well as the cost-benefit ratio of the NMS's investment to be in the order of 16:1 (Sagentia, 2009).

9 Case Study 3

NPL Networks and Clubs bring together companies, instrument end users, academics and user groups. Each network covers a specific area, such as Engineering Measurement or Electromagnetics. They publish newsletters, hold regular meetings and have specialist working groups to share and solve technical problems. They also discuss, commission and carry out collaborative research of mutual benefit and input to national and international associations, along with the production of Good Practice Guides.

The area of radiation and dosimetry illustrates how the outcomes of these activities span the knowledge transfer continuum, from supporting the commercial devlopment of measurement instruments through to delivering benefits related to public good. For example, the Radionuclide Calibrator Users' Forum acts as a focal point for discussion of problems and dissemination of information between users of radionuclide calibrators. It enables participants to pool knowledge and share experience, thereby minimising any duplication of effort when problem solving and implementing best practice.

The group recently published a report on the comparison of Tc-99m measurements in UK hospitals, whereby a wide range of hospitals participated in a study and the ultimate outcome is increased patient safety. The benefits of the club approach were:

- Members had identified and agreed the scope of the potential issue and informed the development of the underpinning work required by the NMS
- Engaged with the hospital community through the club network
- Provided useful information on equipment calibration issues to the instrument manufactures of the network

This is just one example of a large number of NPL Network led activities which engage over 7,000 members with related but different requirements from knowledge transfer.

10 Conclusion

In conclusion, this paper has demonstrated that:

- There is a tendency for knowledge transfer to refer to university – industry interactions, not from knowledge generators more widely or for public good
- NPL and PSRE's are distinctive players in knowledge transfer
- NPL carries out a wide range of knowledge transfer activities, from IP exploitation to science communication, across the continuum of 'shareholders' to 'stakeholders' interests.

Ultimately, what is ***done*** is more important than what knowledge transfer is called.

References

Alavi, M., Leinder, D.E.: Review: knowledge management and knowledge management systems: conceptual foundations and research issues. MIS Quarterly 25(1), 107–137 (2001)

Association of Independent Research & Technology Organisations (AIRTO) 2003 Innovation, Knowledge-Transfer and fiscal Incentives AIRTO website

Bozeman, B.: Technology Transfer and Public Policy: A Review of Research and Theory. Research Policy 29(4/5), 627–655 (2000)

Backer, T.E., David, S.L., Saucy, G.: Reviewing the Behavioral Science Knowledge Base on Technology Transfer. National Institute on Drug Abuse Research Monograph 155 (1995)

Carlile, P., Rebentisch, E.: Into the the black box: the knowledge transformation cycle. Management Science 49, 1180–1195 (2003)

Crow, M., Bozeman, B.: Limited by Design: R&D Laboratories in the US National Innovation System. Columbia Univ. Press, New York (1998)

Databuild Research and Solutions 2005, National Measurement System Impact Assessment (2005)

Evans, W.M., Freeman, R.E.: A stakeholder theory of modern corporation: Kantian capitalism' in Kaler J, 2003 differentiating stakeholder theories. Journal of Business Ethics 46, 71–83 (1993)

Etzkowitz, H., Dzisah, J., Ranga, M., Chunyan Zhou, C.: The Triple Helix model for Innovation: The University-industry-government interaction. Asia Pacific Tech Monitor 2007 24(1), 14–23 (2007)

Etzkowitz, H.: The Triple Helix: University-Industry-Government Innovation in Action. Routledge, London (2008)

Friedman, M.: Capitalism and Freedom. University of Chicago Press, Chicago (1962)

Gibbons, M.: The new production of knowledge: the dynamics of science and research in contemporary societies. SAGE, Thousand Oaks (1994)

Goddard, G.G., Isabelle, M.: How do Public Laboratories in France Collaborate with Industry? New Survey Evidence from France (2006) IMRI Working Paper 2006/02

Gopalakrishnan, S., Santoro, M.D.: Distinguishing between knowledge transfer and technology transfer activities: the role of key organizational factors. IEEE Transactions on Engineering Management (February 2004)

Graham, P.J.: Knowledge Transfer in Theory and Practice: A Guide to the Literature. Published on the Institute of Knowledge Transfer website (2008)

Treasury, H.M.: Lambert Review of Business-University Collaboration – Final Report (2003)

Treasury, H.M.: Lord Sainsbury of Turville "The Race to The Top: A Review of the Government's Science and Innovation Policies" (2007)

Treasury, H.M., DTI, DfES 2004 Science & innovation investment framework 2004-2014 (2004)

Liyanage, C., Elhag, T., Ballal, T., Li, Q.: Knowledge communication and translation – a knowledge transfer model. Journal of Knowledge Management 13(3), 118–131 (2009)

PA Consulting Group on behalf of DTI's NMS Policy Unit, Review of the rationale for and economic benefit of the UK National Measurement System (November 1999)

Prost, J.E., Preston, L.E., Sachs, S.: Managing the extended enterprise: The new stakeholder view. California Management Review 45(1), 5–28 (Fall 2002)

Sagentia Public Sector Ltd. on behalf of Department for Innovation, Universities and Skills Support to NMS Strategy Development: Economic Impact Case Studies, National Measurement Office website: `http://www.nmo.bis.gov.uk/fileuploads/NMS/NMS_Consultation_Doc_Support_Docs_May_09/All_Case_Studies.pdf`

Sloan, A.: My years with General Motors, London, Pan (1967)

Smith, H.J.: 'The shareholders vs stakeholders debate'. MIT Sloan Management Review 44(4), 85–90 (2003)

The Margins of Art Practice Bordering on Industrial Development

Stephen Hoskins

University of the West of England, Bristol

Abstract. One popular view of artists, spread by the media over many years, is of aesthetes with no commercial acumen and a distinct lack of time management! I daresay this popular view has also found resonance with many who work in an industrial context. Examples of this are manifold, from Tony Hancock's 1962 film the 'Rebel' to more recent commentary on Tracey Emin's unmade bed. The truth about artists is actually much closer to one of self-motivated individuals with good self-discipline and a wide-ranging approach to problem solving. This preconception in itself is not the fault of industry; even when dealing with design, the 2005 DTI Paper on Creativity, Design and Business performance states: "Over half of UK firms say design has no role or only a limited role to play in their business"[1]. Why would they want to deal with artists?

So how does a Fine Art printmaking department qualify itself within the arena of developing industrial research projects? Partnerships forged between the Centre for Fine Print Research (CFPR) and industry, now constitute approximately a third of the research work we undertake. These partnerships have grown over the last ten years as the reputation of the Centre has increased. I am specifically referring to collaboration between artists and industry, which develops either new industrial product, or a process that assists the creative development of new markets and profit. There currently exist many Arts and Business and Arts and Science initiatives, which tend to favour the artist and arts practice, what I would like to cover here is the other way round where there are benefits to both parties, (Knowledge Exchange), but weighted more to the industrial benefits and outcomes.

The CFPR specialises in the interface between arts and industry. Our experience of early printing technology and its 19th Century developments give us a fundamental overview of current print technologies and practises, allowing us to take a lateral approach that offers innovative solutions. For example we have run 4 successful KTP's (Knowledge Transfer Partnerships) winning the best 'transfer of technology' award in 2003. Over the years we have undertaken a series of collaborations with big business as well as Small to Medium Enterprise's (SME's). For example with Hewlett Packard our collaborations extend from colour science, through wide format printing to dissemination of research projects with schools.

This paper will highlight this approach and explain how a creative background can offer direct benefits to industry.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 269–276.
springerlink.com

What have Artist Printmakers got apart from the aforementioned self-motivation to offer the print industry (in its broadest context) that it does not already possess? The answer surprisingly is an historic overview of process. Printmaking as a discipline undertaken by artists uses historic processes, because their basic simplicity allows the artist to make prints individually by hand one at a time whilst retaining a wide ranging ability to control the process through the craft skill of the printer. If you start with the premise that all printmaking processes were at some point in the past, commercial processes of their time, you can follow a thread. Therefore commercial print processes are all predicated in printmaking history. For example, lithography, to the Artist printer is the same process developed by Alloys Senefelder in 1796 of grease drawn on a slab of limestone. Whilst contemporary lithography is a computer to plate half tone process capable of printing many thousands of prints per hour, it is still based on the rejection of water by grease. The grease attracts ink whilst the water rejects it. It is therefore not difficult for the artist to follow the development of this process from the limestone slab through to the current four-colour print that prints your Sunday Times magazine.

The other commercial processes familiar to printmakers are equally relevant such as:

Etching – The process of using Acid to bite a metal plate in order to retain ink which through a further process called Photogravure becomes commercial rotogravure; this is the process that prints your chocolate bar wrapper and postage stamps.

Relief print (lino cuts to most people) directly develops to flexography, which prints your cereal packet, cheese wrapper or the giant printed carton your refrigerator or television comes packed in.

Fig. 1 Traditional lithographic stone ready for printing

Screenprint (a stencil process) mops up much of the rest of commercial print. From the cup you drink from, the element that heats your kettle, through to the biomedical sensor that measures sugar content in your blood, all are screenprinted.

This historical context offers two things; one is a fundamental understanding of the basic processes -a fact that should never be underestimated when talking to industry. Secondly it offers core knowledge of how print processes interact with each other and which elements are cross-referential to the other print processes.

To explain, if one thinks of a tree with all of the basic printmaking processes as the trunk, then as each process developed commercially they became branches. As each branch develops its own specific needs they became smaller branches. As considerations of speed and commercial pressures take over these smaller branches develop into specific twigs. Now they are highly specialised and it is at this point that each of the twigs have little or no comprehension of any of the other branches and twigs' methods and needs.

The Academic Artist printmaker therefore can form an important alliance based on that fundamental overview with industry, this alliance is only built with time and care, no business likes an academic upstart telling him he is not doing his job properly and that he, the academic can do it better! However from the artist's viewpoint this has led us to assimilate and develop new methods of making print using both old and new technology.

The sort of work we undertake can be loosely grouped, for the purposes of this talk, into the following areas: Pure Research (funded by bodies such as the Arts and Humanities Research Council) and Applied or Industrial Research – (funded by commissions, bodies such as Technology Strategy Board - through KTP - and direct funding by industry).

Here I will take time to say that we don't only do this work because it is well funded, but in the current educational climate it is also good politics to do this work. Our wider academic standing is high due to the calibre of industrial funding we attract. We also undertake what we call 'projects' which are a mix of research dissemination and public relations. We often produce exhibitions or publications relating to arts practice, these are either self-generating, sponsored or internally funded. Finally there is our own individual art practice and research and as common with most art practice, often not funded at all!

It may also help if these groupings are viewed in the following terms, a research question, a context for the question, a methodology of how to carry it out, and an outcome or result. The pure research poses the question and gives a methodology in order to carry out the research. The industrial liaison gives a broader context for the research and the projects are the result or outcome of the research.

The best example to illustrate our diversity and what we can do for industry is to demonstrate a number of case studies, starting with our relationship with Hewlett Packard (HP). CFPR collaborates on a range of projects with HP, so why UWE and why HP?

First and foremost we understand print technologies separate from and alongside digital technology and our thinking is based upon this broad understanding. Perhaps surprisingly, few people have a broad grasp of the breadth of the print industry and the range of processes available. However we also understand colour science, both from a computational science approach and the creative view of the end user. Very importantly we understand business, timescales, delivery deadlines and costing.

But most importantly we are artists! To quote John Mayer, ex-HP Senior Research Fellow and former head of the print division of HP Labs, “we fund you, as you are not MIT. We fund computer departments and arts schools, but you are neither, you understand practical process.”

One of the aspects that appear at first, to be peripheral to a high tech digital company are the 19th Century processes, photogravure and collotype. Capable of printing in multiple colours, these processes were always the benchmark for the highest quality printing, until very recent digital developments. To take collotype as an example, there are two or three collotype printers left in the world, apart from the CFPR, the last Collotype printer in the UK was in the town of Wooton Under Edge, In Gloucestershire, that closed in Nineteen Eighty Two.

The Collotype process, printed from a glass plate, relies on the hydroscopic nature of bichromated gelatine. Bichromated gelatine hardens in direct relation to the amount of light it receives, which also makes it more or less attractive to water in direct relation to the amount of light it has received.

When exposed through a photographic negative and washed with water the result is a plate that will retain water to differing amounts and therefore reject ink in direct relation to the water retention.

A beautiful and delicate process, collotype died out due to its need for high craft skills. Merely by breathing on the corner of a plate you can change the colour. This is quite unlike lithography, which either accepts or rejects ink and became the dominant process, as it required much less skill from the printer.

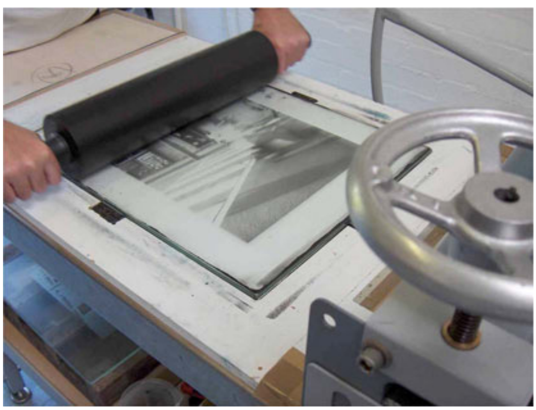


Fig. 2 Glass collotype plate being rolled with ink by hand

Why then is this knowledge important to HP? - Simply because we create standards against which HP can test the quality of their product. Without the wider knowledge of collotype and other processes, your standards are set by commercial print process and the results of your direct competitors in the field. Therefore one only needs to make small incremental changes to make an improvement. By contrast, comparing yourself to the best there has ever been, albeit in some very small niche areas, creates for you a very different standard to try and achieve.

Initially we came to HP in 2000 through their European Art and Science Philanthropy Fund. This fund was set up to undertake a series of projects between, Universities, Museums, Art Galleries and HP; primarily to promote HP's imaging and printing divisions. The group included, the Louvre Paris, the National Gallery London, the photographic archive Fratelli Alinari, Florence, the universities of Strasbourg, Milan, Southampton and (as a late entrant) UWE, Bristol.

Under the scheme HP donated equipment in the form of Wide Format printers, Cameras, and PC's. Importantly the equipment was backed up by access to HP Research Labs and the product development teams. This created a dialogue that remains ten years later. One of the very first projects we undertook was the International Digital Miniature Print Portfolio. Wide format Printing equipment (Here this means ink jet printing equipment capable of printing wider than 24inches) had developed to a level where rapid adoption was beginning to take place within the creative arts, but very little real data as to how users interfaced with equipment outside of the limited reprographic use the products were originally developed for.

The objective of the Miniature Print Portfolio was to encourage collaboration on a variety of levels – between artist practitioners, higher education art students and schools; and the result was the development of new collaborative ventures. In addition to Hewlett Packard - St Cuthberts Mill, Inveresk Paper and UWE also sponsored the portfolio. However underlying the project, the research dimension was to ascertain how and in what ways individuals interfaced with the technology. 80 artists from around the world participated. Each artist sent us a file with an image no bigger than three inches by four inches and we printed 80 sets of prints so that each artist had a complete set as reward for participating, this meant that CFPR printed a total of 6,400 prints. What we learnt was that there were 80 different ways of approaching the technology and 80 different solutions to a problem! As each of the files had been created remotely using whatever technology was to hand, we had no idea of the lack of technology interface that would occur. We solved the immediate problems with a number of 'work around' solutions, to produce an excellent exhibition of prints, but in real terms did not face the problems head on. The artists certainly had no clue of the problems we were facing.

Our next project, known as 'The Perpetual Portfolio' - on the surface an artists residency programme, tackled the problems head on. Eighteen artists were chosen, from a number who applied or were invited and undertook a one-week residency to make a large format digital print with assistance from the research centre. An edition of fifteen prints were created: 5 owned by the artist, 3 by UWE 2 by HP and the remaining 5 sold to raise funds to extend the programme. The artists were delighted with the ability to make a print and own part of the edition, and both HP and our-selves were delighted with the sets of large scale prints we both owned are were able to exhibit. However this was only part of the project, the real intention was to document the process that each artist undertook in order to make their print, as I have explained, when prints were created remotely we had no control over the process. With this project we still did not control the process if we could help it, but rather assisted the artists in whatever methods they used in order to create the print. The primary objective for us was to prove to HP that users interfaced with technology in a very different way, to the way it had been developed. It meant that at the end of the project we had 18 documented case studies of how artists worked, the results were very revealing to HP and certainly informed several aspects of their approach to current technology in wide format printing.

Further collaboration led to HP awarding funding for a two-year post-doctoral researcher, to create software plug-in to allow us to undertake some specific research into colour. They also funded an extension of the Perpetual Portfolio in Argentina where four hundred and fifty artists applied to make a large format digital print with assistance from CFPR at the National Museum of Printing Buenos Aires. Three Artists were chosen and a two-day master class and series of talks were held in the museum during an exhibition of the UK Perpetual Portfolio. Ten years on, we are still conducting strictly confidential research with HP.

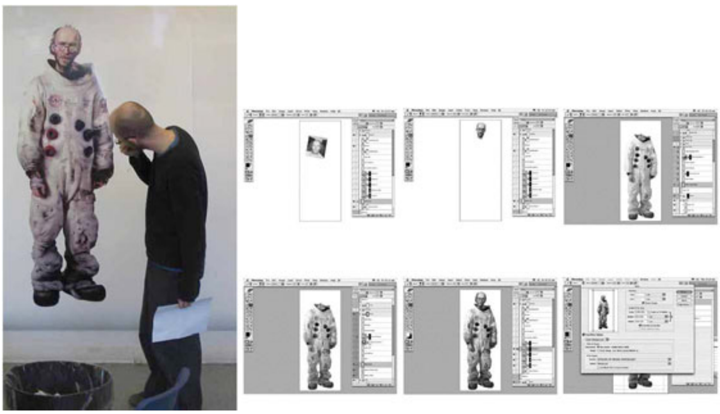


Fig. 3 The Artist Martin Constable viewing his Perpetual portfolio print with some of the process documentation

Another good example of how a project can lead to an unexpected result from what appears to be a relatively straightforward collaboration is demonstrated by a Knowledge Transfer Partnership with the Welsh ink manufacturing company Cranfield Colours Ltd. Cranfield make specialist ink for the print industry but a small part of their business was to make printing ink for artists. This ten to fifteen percent of their business was not only more profitable than the specialist ink for industry, but was also less affected by fluctuations in the marketplace, as many of the customers for these artists inks were colleges and universities who would order a consistent supply of ink annually. However they never met their customers as the inks were distributed through third party vendors. The project was initially about developing healthier ink for the user, formulated as traditional ink that cleaned up with soap and water, rather than more harmful solvents such as white spirit. A secondary element was to develop a methodology for testing these products that more closely matched the needs and methods of use by artists. Part of this element was an attempt to match the terminology of artists to the industrial terminology used by the company chemists. This methodology would serve a two-fold purpose – one, to assist the development of new product and two, to respond more accurately to customer complaints by having a better understanding of the context within which these products were used.

Now, let me give a short explanation of industrial testing methods and the reasons for change. Currently the primary industrial test is to do what is known as a draw down (this consists of drawing a square bladed palette knife of ink across the surface of a commercial piece of paper and then undertaking spectrographic analysis of the resultant film). In commercial terms this is a perfectly valid test and offers a good range of results to the chemist. However when this test is applied to an artist using etching ink it offers no significant information necessary to formulate an ink to the requirements of the artist. Firstly the artist will heat the ink before use, therefore changing its viscosity (thickness or length in artists vocabulary). Then he/she will force this ink into a copper plate with a rag, correctly known as scrim, this can oxide the colour and change its physical appearance drastically. Then he/she will wipe the plate clean by hand, thus adding grease to the surface film. Finally the artist does not even print it on a dry smooth piece of paper but insists on printing it onto a piece of wet hairy stuff made from cotton linters, known to artists as mould made printmaking paper, not the usual cellulose wood pulp that creates cheap copy paper. You begin to see the problems!

Before we could even deal with these differences we needed to create a common language. What Cranfield called ‘viscosity’ artists used words such as ‘buttery’ or ‘thin’, likewise ‘tack’ was described as ‘short’ or ‘sticky’, both parties are using correct terms within their respective fields, but cannot communicate across the different disciplines.

The Director of Cranfield, Michael Craine, summarises the problem with an anecdote of an employee trying to book a hotel room in France. There was a price difference between a room with a bath and a room with a shower. The employee enquired what is the difference between the bath and the shower. The hotel proprietor replied “in the shower you stand up, in the bath you sit down.”

To tackle these problems we needed a very hands on solution, which both made sense to the factory employees and gave them confidence in the product they were manufacturing, in order for them to respond favourably to any complaints or questions. The solution was to develop a manual of terms, teach all of the factory employees real, hands on experience of the basics of each of the processes they were making ink for. Then the company installed small presses in the factory to undertake real term tests alongside the factory tests, until they had gained real confidence in why they were making the product. Cranfield’s market share of artists ink market has increased substantially and the water washable ink called ‘Safewash’ has widened their global market and sells well in the USA.

So, What do we as artists and researchers get from a project? In this particular case it has resulted in the reformulation of ink for the collotype process, greatly assisting an AHRC research project that without this industrial liaison would never have been possible. Other outcomes have been assistance with developing ink for use by artists in developing countries that can be made to a professional standard using locally available materials and I wrote a book on ink for artists!

The above projects are in some senses relatively mainstream with a visual arts environment and this continues, for example we have recently completed a ‘Medal of Dishonour’ for the ‘Pop artist’ Richard Hamilton, which is currently on show in the British Museum. This medal, cast in silver, made use of the centre’s 3D rapid prototyping technologies.

More unusually we are increasingly being asked to undertake technology transfer with companies who are not print related, but for whom the addition of printing to their product adds real value. For example we are currently undertaking a KTP with a company who make high performance, contamination control floor coverings and mats. They approached us to install digital wide format print technology, so they could print company logos and advertising onto the mats as an integral part of the production process. This KTP project has recently expanded as the company has realised there are simpler ways of manufacturing their flooring based upon technologies already extant in the printing industry, a radical departure for the company.

Additionally we currently have a project of physically printing in 3D scans of broken bones for the NHS to enable surgeons to visualize, in real terms, multiple fractures and how best to repair them.

In conclusion, the intention was to demonstrate that a creative approach to problem solving has direct benefits to industry. Whilst the visual arts, in its traditional forms has its own culture and defined economic benefits, interdisciplinary applied research has distinct benefits to all involved. Without undertaking this industrial research, which gives outcomes that are easily defined as benefiting the wider economy, it can be hard to justify to a wider audience the financial benefits of visual arts research. These case studies I hope demonstrate directly the cultural and financial benefits of working across boundaries that are increasingly becoming more blurred as technology develops. Conversely most of this work relies on an understanding of a practice led craft skill approach to problem solving. In an era of rapidly expanding technology we must not forget the value of physical hands on problem solving.

Reference

[1] DTI Creative Economics Paper No. 15 Creativity, Design and Business Performance. DTI/Pub 8054/0.8k/11/05/np. URN 05/1676 (November 2005)

The Manifesto of Possibilities: Commissioning Public Art in Urban Environments

Cameron Cartiere

Birkbeck, University of London

1 Introduction

The Manifesto of Possibilities is a statement of beliefs, concerns and recommendations about the commissioning of public art in urban environments. It has been developed from research by Cameron Cartiere and Sophie Hope and is a knowledge transfer mechanism that aims to inspire reflection, discussion and cohesive action for all those involved in commissioning public art.

Increasingly people working in diverse aspects of contemporary urban society (from property developers to park wardens) are turning to the arts for new ideas, in regeneration, problem solving and community bridge-building. The employment of artists in traditionally non-cultural fields, where there are other non-artistic issues and agendas at stake, is becoming the norm.

The development of the *Manifesto of Possibilities* provides a timely opportunity to address the uncertainties of commissioning art in such a context, together with a forum to explore academic research, discuss crucial concerns, and devise tangible solutions. Central to the project is that the Manifesto document enables this research knowledge to be presented in a meaningful way to key decision makers and practitioners in the field of public art with the aim of effecting change in the manner and methods in which contemporary public art is commissioned.

2 The Manifesto as a Democratic Process

Man-i-fes-to • *noun* (pl. manifestos): A written declaration of intent or principles; a public declaration of principles, policies, or intentions; a proclamation of opinions and motives.[1]

The crafting of a manifesto is a well established tradition in the arts. The Symbolist Manifesto (1886, Jean Moréas), St. Cloud Manifesto (1889, Edvard

[1] This definition compiled by the author from definitions of 'manifesto' in the Oxford English Dictionary, Merriam-Webster Dictionary, and Dictionary.com, and reflects the spirit of the development of The Manifesto of Possibilities.

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 277–285.
springerlink.com

Munch), Manifesto for the Futurist Painters (1910, Uberto Boccioni et al), Manifesto of PREsentism (1920, Raoul Hausmann), DADA Manifesto (1920, Francis Picabia), Yellow Manifesto (1928, Salvador Dalí), Manifesto of Spatialist Art (1951, Lucio Fontana, et al), Chelsea Hotel Manifesto (1961, Yves Klein), Fluxus Manifesto (1963, George Maciunas), Maintenance Art Manifesto (1969, Mierle Laderman Ukeles) – this list is just a sampling of an extensive history of artists voicing their beliefs, positions, thoughts and concerns. Through these statements, the authors strived to convince, convert, change, and challenge the accepted practices of their time. The art manifestos of the early and mid 20th century were the public declarations that launched movements and became a crucial vehicle for the voice of artists. These modern manifestos were also a means to convey practiced-based research derived from countless hours in the studio and in the field. However, in a post 9/11 political climate where even the word 'manifesto' might be considered subversive, extremist or simply unpatriotic, can artist manifestos maintain their ability to influence art practice and policy? Is the artist's role to question, now itself in question? This essay examines the possibility of the art-based manifesto as a knowledge transfer device and what strategies can be implemented to facilitate such an exchange.

Beyond the stigma of political rhetoric, the query remains -- can the contemporary manifesto serve as a vehicle for change? Recently there has been an infusion of new manifestos specifically focused on art in the public realm that call into question in the fundamental nature of the public art process. This essay bridges the tradition of art manifestos of the past to current practices by exploring four contemporary public art manifestos: *An Open Letter to Arts Administrators*, (November 2006); *15-Point Unofficial Manifesto for Telling the Truth about Public Art*, by Jeannene Przyblyski, San Francisco Bureau of Urban Secrets (2006), *A Manifesto for the Public Realm*, produced at the Art U Need Artist Seminar led by the artist, Bob & Roberta Smith, Rochford, Essex, England (March 2007); and *The Manifesto of Possibilities: Commissioning Public Art in the Urban Environment*, co-authored by Cameron Cartiere and Sophie Hope, London, England (2006-2008). Through a comparison of not only the content, but also the process by which these different manifestos were developed, prepared and presented, this essay presents knowledge transfer strategies for practitioners, commissioners, and researchers to navigate their way through the maze of challenges, negotiations and compromises intrinsic in the public art profession.

3 A Call to Arms

In November 2006 over 125 artists from across the USA, who worked extensively in the public realm, signed the *Open Letter to Arts Administrators*. This letter was a call to public art administrators to re-examine some of the commissioning and contractual practices that have evolved over the last few decades which the signatories believed were unfair to artists. The letter addressed specific and critical issues such as copyright ownership, Requests for Proposals (RFP) versus Requests for Qualifications (RFQ), insurance, contracts, and conceptual design. The authors intended the letter to serve not as an act of rebellion but as a means to improve the working relationship between artists and arts administrators. The letter opens with the following statement:

> "We offer, by this letter, commentary and recommendations that we believe will make the partnership between artists and administrators more effective and efficient, resulting in art works that are more evocative of our time and place. We do not pretend to speak for all artists, indeed, many of the undersigned may not necessarily agree with all the points raised below. However, our collective experience has now taken a voice that we hope may speak to many concerns within our industry."[2]

The letter goes on to address specific issues and offer plausible solutions to amend the conflicting practices. Many of these recommendations were founded in practice-based research by the artists involved in drafting the letter.

In the same year that the Open Letter was being developed, Public Art Review published the *15-Point Unofficial Manifesto for Telling the Truth about Public Art*, by San Francisco arts commissioner Jeannene Przyblyski. In addition to being an arts commissioner, Przyblyski is also an artist and cultural historian and she offered a manifesto that was clearly from her personal perspective. Each of the fifteen points begins, "I am for a public art that…" such as "I am for a public art that aspires to rise above the stature of the merely 'appealing.'" Or, "I am for a public art that challenges itself to go beyond the mere display of historical artifacts in order to tell a story" and "I am for a public art that never offers the spectacle of technology alone to address the complexity of urban life."[3]

On the other side of the Atlantic, two very different public art manifestos were developing between 2006 and 2007. *The Manifesto of Possibilities: Commissioning Public Art in the Urban Environment* is a discussion document that takes the form of a mind map. Similar to the Open Letter, this manifesto addresses specific components of the public art process including the artist, the community, and the commission. It also incorporates additional areas such as the evaluation, the art, and the curator. Ideas and positions raised in the document include, "Public art is NOT a single art form. There are a multitude of approaches, methods and motivations for public art. Acknowledge and celebrate the depth and breath of the field" and "Public art is not a universal problem solver for poor urban design or a magic formula to solve social injustice. It needs to be recognized that good public art is not a single substitute for good public policy" and "Artists work with communities but not subsequently for them. The role of the artist is not necessarily to create communities but rather to make connections."[4]

As part of the project *Art U Need*, developed by Bob and Roberta Smith, a one-day seminar was held for artists in South-East England specifically to create a manifesto for public art. The introduction to the manifesto produced at the seminar

[2] Originally published in Public Art Review, Spring/Summer 2007, pdf. version available at http://classic-sculpture.com/open_letter.htm

[3] Jeannene Przyblyski, 2006. 'Been There? Done That? An Arts Commissioner Tells Some Truths About Public Art,' Public Art Review, no 18, Fall/Winter, p. 69.

[4] www.manifestoofpossibilities.co.uk

has a markedly different tone from the Open Letter: "This manifesto will be inclusive of all buzz words and spin. All boxes will be ticked. All recipients' views will be listened to and evaluated."[5] The manifesto goes on to address similar areas of concern to the Open Letter, including commissioning and the artist's role in the process of developing public art. However, this manifesto is more of a free-form mixture of short statements and questions such as, "Artists will make small and large transformations to communities; Love the space between the Public and the Artist; Is there a place for Art for Art's Sake in public art?; Artists will not be go-betweeners; [and] There is nothing wrong with Barbara Hepworth."[6]

All of these manifestos are trying to address some of the key issues and concerns facing artists working in public art today, yet some have been much more effective than others at producing dialogue, knowledge transfer and the potential for change. Two documents looked at the challenge strictly from the perspective of the artist. One presented the voice of the arts administrator and one presented a collective voice. The position of the Open Letter and the Art U Need Manifesto were clearly drafted from the artist's perspective yet the former received international attention while the latter remains relatively obscure.

4 Answering the Call

While the *Open Letter to Public Art Administrators* does not profess to be a manifesto, it is included within the context of this essay as it does present a very public statement of opinion and intent, in an attempt to bring about change. The letter grew from the discussions of a handful of artists in the USA about issues they were facing in their public art practices. Those initial conversations evolved into discussions with a broader national artist group that ultimately resulted in the letter. The Open Letter was subsequently published in the Spring 2007 issue of Public Art Review. Along the way the letter was posted online at The Social and Public Art Resource Center website and artists could add their signature to the letter. What was unique about this letter, and what distinguished it from other forms of manifestos, is that it not only raised a set of issues, it offered tangible recommendations to address the issues raised. Rather than just 'drawing a line in the sand' the authors crafted the letter in a manner that actively invited dialogue, and the publication of the letter generated numerous discussions on the Public Art Network listserv, a major resource for public arts administrators across the country. The letter was also unleashed online and was quickly forwarded from one artist to another around the globe. The letter was cross-posted on other sites and offered as a free download in multiple formats. The formula of a well-argued statement combined with global distribution made it very difficult for the content of the letter to be ignored.

According to the authors, the listserv publication resulted in artists and program managers holding salons across the country to draft professional standards they

---

[5] Smith, Bob. 2007. *Art U Need: My Part in the Public Art Revolution*, London: Black Dog Publishing, p.168.

[6] *ibid*. pp.168-69.

would like to see adopted within the public art field. This grassroots movement led the artists to propose a panel at the Public Art Network / Americans for the Arts 2008 Annual Conference in Philadelphia. The panel, called 'What Do Artists Want?'[7], was attended not only by artists, but equally by public arts administrators from very large, established and influential public art programs, as well as academics and writers. Clearly the letter had struck a cord that was resonating through the public art community on both sides of the aisle. Even the disruption caused by a fire alarm that forced the evacuation of the conference centre did not discourage the group, as they simply picked up an easel and large notepad and continued the panel discussion outside on the sidewalk until the 'all clear' was given.

The Art U Need manifesto was also developed as a group process with artists. However, the format and intention of the document was fundamentally different from the development of the Open Letter, as well as the *Manifesto of Possibilities* that also incorporated a collective voice. The Art U Need manifesto was developed as part of a larger project by artist Bob and Roberta Smith called 'Art U Need: An Outdoor Revolution.' Smith was the "curatorial artist" in charge of the overall project that utilized a series of commissioned works by five other artists[8] working with local people to create site-specific works for five districts[9] in the Thames Gateway based on the history, heritage and culture of each locale. The project also included educational programs, and the manifesto was the result of a seminar led by Smith for 24 artists from Essex. The seminar was only open to artists from the region and at the writing of this essay the manifesto has yet to be published online[10]. The only public access to 'A Manifesto for the Public Realm' is by purchasing Smith's book, *Art U Need: My Part in the Public Art Revolution*[11]. The book is a diary by Smith of the entire project and the manifesto is presented on two pages of the 160-page text. While the manifesto does make some provocative statements such as "Creativity (non-social, non-educational) is an integral part of regeneration" and "Art will be informed by what we can't do," overall it is handicapped by the very nature of its design: It is a document with a very limited public voice and an equally limited public audience. Many of the statements such as, "The artist will have a personality" are puzzling and opaque. What artist does not have a personality and when has that personality not been expressed in some way through their practice? With a plethora of art historical examples from Michelangelo to Picasso, and on to contemporary artists such as Louise Bourgeois, Antony Gormley, or even Smith himself, one could easily argue that artistic personality and vision are at the core of artistic expression.

---

[7] Panel presenters were Lynn Basa, Artist, Basa Projects, LLC; Barbara Hoffman, Attorney, Covington & Burley, LLP; Jack Mackie, Artist; and Porter Arneill, Director/Public Art Administrator, Kansas City Municipal Art Commission.

[8] The five artists were Lucy Harrison, Andrea Mason, Milika Muritu, Hayley Newman and Jane Wilbraham.

[9] Castle Point, Basildon, Southend, Rochford and Thurrock.

[10] The website for the Art U Need project is www.artsgenerate.org.uk/resources/art-u-need.html

[11] Smith, Bob. 2007. *Art U Need: My Part in the Public Art Revolution*, London: Black Dog Publishing.

In developing the *Manifesto of Possibilities*, a similar workshop approach was implemented but with a different intent and outcome in mind. This manifesto was the result of research conducted over eighteen months through a series of seminars, workshops, and online forums that actively engaged over 400 participants. The project began with three interdisciplinary seminars, organised by Cartiere as part of the *Building Cultures* series and sponsored by the London Centre for Arts and Cultural Exchange (LCACE)[12] that examined the role of public art in community engagement, regeneration, and activism. The series brought together artists, educators, politicians, and community activists, to take an expansive look at the role of public art in a rapidly changing city. This holistic perspective was a fundamental aspect of the methodology throughout the project.

The first session occurred on 8th May, 2006 at Tate Modern and focused on Public Art and Community Engagement.[13] The discussion focused on evaluation trends as well as the concern that 'calls for proposals' and pre-evaluation checklists are too all-encompassing and unrealistic. Artists in the audience were concerned that when they prepared a proposal for a public work, they also needed to demonstrate how the work would inspire a community, reduce crime, respond to the environment, contribute to urban renewal and/or support rural sustainability, provide educational and cultural opportunities and inspire debate without being confrontational. In many instances, both the audience and the discussants observed that these wide-ranging criteria were often being applied regardless of the scale of the commission, be it a monumental sculpture, a socially engaged community event, or an artist-designed bench.

The second session was held at the Greater London Authority on 16th May 2006 and focused on Art, Community, and Urban Regeneration.[14] Under the weight of London's continually rising house prices and the upcoming 2012 Olympic Games, poised to radically change the landscape of the eastern reaches of the capital, the discussion turned towards concerns about mass redevelopment, community displacement at the proposed Olympic venues and the homogenization of the remaining unique neighbourhoods that currently surround the Olympic sites.

The third and final session took place at Whitechapel Gallery on 24th May 2006. The focus of the evening was Art Activism and the Community.[15] The central questions of the evening revolved around concerns of how to maintain community involvement over an extended period, finding true representation in the political arena, and fostering change through slow activism.

---

[12] Formally the London Centre for Arts and Cultural Enterprise.

[13] Session one, chaired by Cameron Cartiere included panel participants Peter Fink (Art2Architecture), Sophie Hope and Sarah Carrington (B+B), Alan Rossiter (Freeform) and Louise Wardle (Channel 4's Big Art Project).

[14] Session two, chaired by William Ackah and Penny Koutrolikou, featured panel members Isabelle Fremeaux (Birbeck), Anna Harding (Space Studios), Ben Seymour (London Particular) and Justine Simons (Cultural Strategy Manager, Greater London Assembly).

[15] Session three, chaired by Professor Annie E. Coombes included Jane Trowell (PLATFORM), Baroness Lola Young of Hornsey, (Birkbeck) David Beech (Sheffield Hallam University), and art activist Poulomi Desai.

One of the common concerns that surfaced across the series was that throughout the past decade there has been a repeated call from funders for public art to educate, re-brand, and creatively consult communities. The concern for many people working in field is the need for more realistic expectations of art in the public realm and sharper analyses of the wider economic and political context in which the commissioning of public art is taking place.

The initial hope for the series was to go beyond the common 'one-off' evening panel discussion and create an opportunity for an extended conversation around some of the key issues facing artists working in a publicly-engaged practice within the city's current social and political climate. Over the course of the three evenings a significant percentage of the audience returned, panel members from earlier sessions voluntarily became audience members in subsequent sessions, and the overlapping concerns of community engagement, urban regeneration, and art activism bubbled to the surface of the discussions without having to be forced to a boil by the respective panel chairs.

At the end of the seminar series there was a feeling of success in creating an opportunity to take the conversation beyond previous limitations. Hours of video documentation and strong themes had emerged throughout the course of the series. There was certainly enough material to craft an interesting document. However, one of the underlying research questions was whether it was possible to create an effective manifesto through a group process – a question that mirrored how many public art projects are developed. Yet, rather than organizing a further series of panels or review committees, a more proactive approach was adopted, leading to an action workshop aiming to produce something tangible to benefit our greater community. Participants agreed that it was crucial not to limit the workshop to just artists; that it was important to maintain a holistic perspective and work with participants from across the spectrum of the public art process. Therefore whilst participants certainly included public artists, architects, commissioners, administrators, developers, educators, and community leaders were equally represented.

Knowledge transfer is often perceived as an exchange from academic to practitioner; however, we also had an opportunity to create a knowledge transfer event where practice could influence theory just as readily as theory influences practice. At the workshop, held in February 2007, great pains were taken to emphasise to all participants that their active involvement was crucial to the development of a set of action points that could be taken forward into a manifesto document. The session began with a presentation of the dominant themes that emerged from the three previous events. These six themes were: The Changing Roles of Public Art, Public Art and Urban Renewal, Regeneration and Gentrification, the Public Art Profession, Evaluation, and Public Art as a Negotiating Power. The delegates were divided into break-out groups and given the task of devising at least two action points which would address concerns in each of the six areas; an ambitious task and one which created much heated discussion.

The strategy yielded excellent results, with each group presenting a set of action points for wider debate in a chaired feedback and discussion session. Proposed action points included calls for artists to be designated equity with other professionals involved in public art projects, the development of systems to allow knowledge-sharing, particularly in reference to models of evaluation and best practice, and the recognition of the importance of risk in delivering successful public art projects. The action points that were generated at the workshop formed the foundation of the manifesto. An online draft version of the manifesto document was launched on May 1, 2007 in the form of a 'wiki'[16] and for two months there was an opportunity for individuals to actively discuss and shape the content. The wiki also served as an arts and community resource with links to other manifestos, public art organisations, and publications.

The resulting Manifesto has six sections: The Commission, The Artist, The Curator, The Community, The Art and The Evaluation. Each section consists of short statements of intent distilled from the seminar, workshop and online discussions. Its format as a poster is intended to reference the revolutionary roots of manifesto writing, a certain nailing of ones colours to the wall. The Manifesto is intended for commissioners of public art (public and private sectors), curators, educators and facilitators of public art, artists, agencies of public art, evaluators, policy makers such as Arts Council England, DCMS, Mayor of London and other central players in policy making, those promoting the role of art in urban change, and funders of public art.

As a poster, the Manifesto becomes a focal point for partners in the decision making process; a tool to back up arguments or simply a reminder to ask key questions during the commissioning process. From the outset it has been important to recognise the unique quality of every commission and this is reflected in the Manifesto's composition. It does not aim to be a checklist or set of fixed guidelines, but rather it acknowledges failure, rebellion and risk taking as an essential part of the commissioning process, that everyone can learn from.

At its most basic level the *Manifesto of Possibilities* provides a set of coordinates which public art practitioners can use as navigational cues indicating the position of their own practice, and in this way inspire re-evaluation or a new critique of established methodologies. The action of publishing the Manifesto is by no means intended to be definitive, it is meant to create room for reflection and disagreement. While the Manifesto starts from the position that the commissioning of public art should be encouraged, it also invites us to question this fundamental premise along with the objectives and methods of any commission. Equally, each of the Manifesto sections could be expanded, re-organised or abandoned depending on individual positions or experiences. Most importantly, by sharing this statement of beliefs, the *Manifesto of Possibilities* creates a context in which such questions can be asked.

Similar to the Open Letter, the aim for developing the *Manifesto of Possibilities* was to identify areas of concern within current public art practice and present tangible recommendations from this 'community of common interest' for ways forward in future projects. Unlike the Art U Need manifesto, the creation of the *Manifesto of Possibilities* does not represent the end of the argument; rather it is

[16] www.manifestoofpossibilities.co.uk

intended to engage all those working in the public realm in joining a continuing debate.

This is not to say that only manifestos generated through a group process have the ability to impact industry thinking or effect real change. The *15-Point Unofficial Manifesto for Telling the Truth about Public Art* is a powerful and thought-provoking document with a clearly discernible argument. Przyblyski may temper the political punch of her title by referring to her manifesto as "unofficial," but its content goes to the heart of the artistic angst of public art. Point number 14 speaks most clearly to the central fear that lies beneath many committee decisions that result in banal public art: "I am for a public art that is energized by controversy, that doesn't go looking for it, but doesn't run away from it either, and will not consent to go quietly into mediocrity. Quality may mean many things in many different contexts, but it certainly means something in the end: You should be willing to fight for it (see no. 12)." Point number 12 reads: "I am for a public art that believes with all sincerity that risk is a permanent condition." Perhaps it is Przyblyski's dual role as artist and arts commissioner that enables her to speak with such equanimity to both public arts administrators and public artists. Like the Open Letter, her unofficial manifesto was published in Public Art Review[17] and is easily accessible online. This ready accessibility has also contributed to the wider influence of her unofficial manifesto within the field.

In the course of utilizing the medium of the manifesto as a vehicle for expression and change, it is not enough just to articulate one's opinion or to exercise an individual voice. The real question is what one is going to do with that voice. Artists need to do more than just utilize the manifesto format as an artistic exercise. In order to claim any lasting power in the debate, artists need to be willing to do more that just point out the problems.

Knowledge transfer is a process of exchange that, at its best, allows for mutual exchange of information, experience, and application; therefore artists engaged in this process need to contribute to a longer and very public conversation and be willing to participate in the work of finding mutually beneficial solutions. Indeed, since the launch of the final version of the *Manifesto of Possibilities* on January 31, 2008, the document has had three printings, totalling 15,000 copies. The manifesto is also available as a free download from the website[18] and to date over 8,000 copies have been downloaded. It has been used in both Japan and Taiwan to draft proposals for national public art policies. It has been used in New Zealand to train public art curators for a series of twenty-one projects across the country. It is used by educators in art schools around the globe, as an assignment for students interested in public art and, perhaps most importantly, it graces the walls of the offices and the studios of thousands of public art administrators and artists as a ready tool for exchanging knowledge, practice, and new ideas for commissioning public art projects large and small.

---

[17] Jeannene Przyblyski, 2006. 'Been There? Done That? An Arts Commissioner Tells Some Truths About Public Art,' Public Art Review, no 18, Fall/Winter, pp. 68-69.

[18] www.manifestoofpossibilities.co.uk

Exploring the Safety of Knowledge Transfer from University Hospital to "Real-Life" Doctor-Patient Treatment Environs

Professor Simon B.N. Thompson

Bournemouth University, Talbot Campus, Poole House, Fern Barrow, Poole, BH15 1YE, UK
e-mail: simont@bournemouth.ac.uk

Abstract. Knowledge transfer (KT) is widespread across most university interfaces particularly between university and industry and increasingly with hospitals and other medical/patient environs. As KT becomes more varied and diverse, safety implications become more abundant and more diverse. There is a responsibility and an increasing importance for examining the qualifications and experience of the end-user and the extent of possible misuse or dangers of the commercial product. The question over whether a product successfully transfers from academia to industry or "real-life" application is no longer key; rather, whether or not essential knowledge successfully transfers with the product.

1 Introduction

The governance of knowledge transfer (KT) activities due to the reorganization of European universities has been comprehensively examined by Geuna and Muscio (2008). The authors discuss how interactions between university professors and companies can be traced back to the development of the chemical industry in the nineteenth century. They suggest that the first "academic revolution" was the introduction of research together with teaching (for example, the Humboldtian transformation) where everyone employed in a university was involved in both research and teaching.

Increasingly, universities are faced with economic viability and the need to consider the merits of teaming up with collaborators in research or industry partners that may progress ideas to production and services. In the past, industry, particularly the pharmaceutical industry, has maintained keen links with university research departments and centres to investigate new innovations that may possibly be progressed to market as commercially viable products. In the UK, hospitals have also been welcomed into closer collaborative links with academic establishments through the formation of University Hospital Trusts and Foundations that forge strong research and teaching links between academia and "real-life" evidence-based practice approaches (Editorial, 1996; Trinder & Reynolds, 2000).

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 287–292.
springerlink.com

As early as 1975, the National Science Foundation which supported basic research in US universities, established the first set of University-Industry Cooperative Research Centers (UICRCs) intended to be the locus of university-industry interaction (Geuna & Muscio, 2008). The first policy action in Europe was seen in the 1980s by the Alvey programme in Information Technology (IT) (Oakley & Owen, 1990). However, the individual characteristics of researchers often have the strongest impact upon connections with collaborative partners (Murray, 2004; D'Este & Patel, 2007; Siegel, Wright & Lockett, 2007).

The growing mass of innovators and commercially-backed projects also carries with it a huge risk. For example, whilst products are being invented, designed and developed by the innovators they belong potentially in "safe hands". However, as products progress towards applicability and commercial viability, they may be used and handled by lesser qualified or knowledgeable personnel. The list of (non-exhaustive) potential safety implications is dependent upon product type, application and use, end-user, exposure to other personnel, ease with the which the intended design may be changed (for example, in a disadvantageous or dangerous way), possibility and scale of potential misuse, risk of deleterious consequences, etc.

The saying "knowledge is dangerous" may have some validity under certain circumstances. However, equally useful is knowledge that advances are understanding and the use of knowledge that informs consent. Such issues are particularly pertinent in medicine and in the application of rehabilitative devices that seek to improve patient welfare in a number of healthcare environs, for example, in occupational therapy centres and neurological rehabilitation, particularly for the rehabilitation of stroke patients and physical trauma patients.

For some time at the University of Portsmouth and now at Bournemouth University in the UK, we have been investigating the application of novel devices for use in the rehabilitation of leg injuries, such as those obtained through snow skiing, surgical intervention and removal of leg carcinomas and lower limb incomplete innervation in cerebrovascular accident (stroke) patients.

This has involved the collaboration of university, local and distant hospitals, and ministry of defence establishments within the UK. The focus has been on the development of an "expert system" that has the potential to inform practitioners about treatment strategies and prognosis.

2 Method

Starting in the late 1980s, ongoing investigations have focused on the reaction times of the quadriceps muscle group, situated in the upper thigh, of adult stroke patients who were admitted as out-patients to the occupational therapy department of Queen Alexandra Hospital, Cosham, Hampshire, UK (Thompson, 1987a; Thompson, 1998; 1999). Subsequent research involved collaboration between the University of Portsmouth, UK; Salisbury District Hospital at Odstock, Salisbury, UK; Nottingham City Hospital, Nottingham, UK; Royal Naval Hospital Haslar, Gosport, UK and now Bournemouth University, UK (Thompson, Coleman & Yates, 1986; Thompson, 1987b; Thompson & Coleman, 1987; 1988; 1998).

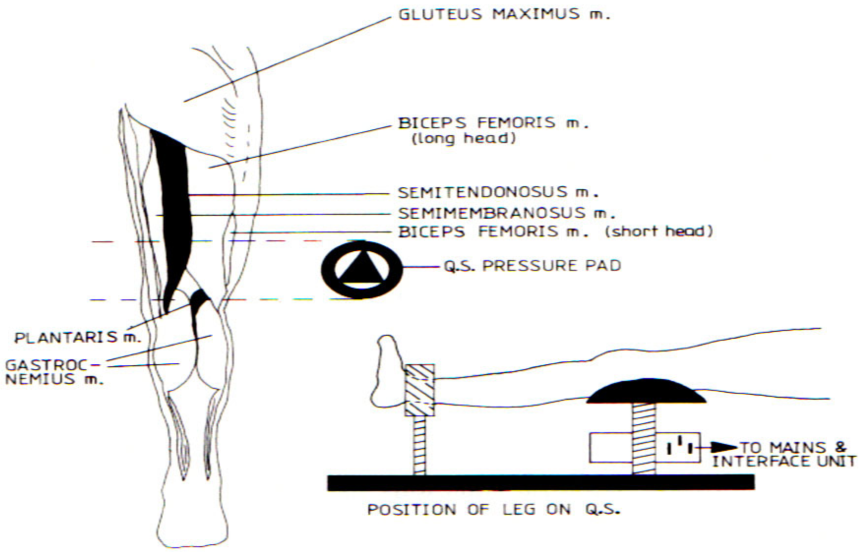


Fig. 1 Measuring nerve impulses in the leg muscle

The need for a faster interpreter of muscle movement was decided after a pilot study had been conducted using a piece of hospital-based portable therapy equipment (quadriceps switch), computer and electromyography (EMG) used to measure muscular electrical nerve activity (Figure 1). The former device had been used as basic therapy equipment in a number of hospitals in Belfast, Northern Ireland, for the rehabilitation of damaged thigh muscles resulting from gunshot wounds consequential to separatist and terrorist activity. The device was considered beneficial for similarly disposed patents suffering as a result of a stroke and also for leg traumas resulting from snow skiing accidents and surgical interventions (Thompson & Morgan, 1996).

The Thompson Digital Switch (Thompson & Coleman, 1989; Thompson & Morgan, 1996; Thompson, 1999) was designed and developed to accurately and quickly detect and interpret very fast signals obtained from a specific neuromuscular site on the leg muscle. The nervous electrical activity was used to produce a range of graphics displays that feedback to the patient information about the status of the muscle group during exercise. For example, a moving lorry across the computer screen signalled the achievement of a muscular contraction whilst a stopping lorry showed that the leg muscle had relaxed.

Variations in displays and tones elicited to cue the patient into performing a short contraction during therapy were designed and validated. The apparatus was successfully used with stroke patients and large break leg injuries such as snow skiing accidents particularly where the tibia had been broken. Leg muscle that was reduced as a result of surgical intervention to remove carcinomas in the gastrocnemius muscle also benefited from this device (Thompson & Coleman, 1987c). In 1989, the Thompson Digital switch was rolled out commercially by Digital Services Ltd, Portsmouth, UK, with a target market of UK hospitals and research establishments.

3 Results

Early feedback indicated that there was a lack of knowledge amongst users of the device. This situation necessitated product advice and use. Historically, use of biofeedback devices meant widespread exposure in the 1960s to early proprioceptive devices that detected and made use of brain alpha waves to power small scale circuitry such as model trains around a train track. These feedback systems typically had limited application, but at least gave clinicians familiarity with feedback systems. Users of the Thompson Digital Switch needed demonstrations that included the scope and versatility of the device in a number of different therapeutic settings.

It became clear that a comprehensive manual needed to be produced together with in-house training. There was also the possibility of clinicians not using the feedback system to the best of its capabilities. For example, a series of tones were issued during a typical rehabilitation training programme that required the patient to produce a leg contraction using the large muscles of the thigh, namely, the rectus femoris, tibialis, lateralis and medialis. The quadriceps tendon was situated on the micro-switch pad on the quadriceps switch device.

In some cases, patients produced a sustained contraction despite being signalled to relax. Long-term contraction in early recovery patients could possibly produce contractures resulting in the patient having reduced mobility due to damaged muscle. Therefore, it was critical to operate this device correctly and with correct instruction to users. Initially, the device was limited for use by trained physiotherapists and occupational therapists or other qualified healthcare personnel. A rich picture was produced using Checkland's Methodology (Checkland, 1981) to help understand how this new rehabilitation would impact on the whole process of neurorehabilitation. As knowledge about its correct use and together with an instructive manual and demonstration, the device and system was then rolled out for use by other responsible users.

Current examination is focussing on updating the device and system and its aggregated use with other systems for the compilation of an expert system for therapeutic prognoses.

4 Conclusions

The transfer of knowledge from domains is a responsibility. Knowledge transferred should be made clear in terms of both clarity and purpose in order to avoid misinterpretation and ambiguity. Risk assessment becomes important especially where patients' recovery is involved. Constant monitoring is also important between the original domain, in this case the author (designer and developer of the device) and end-user. Where this is not possible, demonstration and instruction should be carried out supported by comprehensive and well-written instruction manuals.

Although there is evidence in support of knowledge flows (Grant & Gregory, 1997) and informal contact between academic establishments and industry (Bozeman, Papadakis & Coker, 1995), there is little guidance on the safety and transmission of knowledge and the protection of end-users of products, particularly new products. Notably exceptions are for specific devices in the forms of product information but general rules or guidance on the transfer of knowledge is not apparent. However, it is acknowledged that patents and licences may address some issues (Agrawal & Henderson, 1992; Siegel, et al., 2003), and safety regulations address issues of conformity.

It is perhaps the diversity of information transferred outside academia that makes it difficult to make regulations uniform. The example of the Thompson Digital Switch is therefore relevant in highlighting the difficulties of informing its correct use together with the protection of patients who will ultimately use the system.

Whilst University Technology Transfer Offices (TTOs) bridge academic institutions between academic scientists and researchers and those in industry, they may be trying to hard to cover the depth and breadth of academia. However, undoubtedly, as Conti and Gaule (2008) state, they play a key role in the translation of research results into economic outcomes. In a recent survey of 355 European universities, it would seem that national laws and policies on technology transfer, including issues such as professor's privileges (Guldbrandsen & Smeby, 2005) impact upon knowledge transfer from academia to industry (CMT, 2009). Ultimately, it will be down to the ethical considerations and morality of designers and implementers of systems that govern the success and responsible knowledge transference.

References

Agrawal, A., Henderson, R.: Putting patents in context: Exploring knowledge transfer from MIT. Management Science 48, 44–60 (2002)

Bozeman, B., Papadakis, M., Coker, K.: Industry perspectives on commercial interactions with federal R & D laboratories: Does the cooperative technology paradigm really work? Research on Science and Technology Program. Final Report to the National Science Foundation. Contract No. 9220125. Georgia Institute of Technology, Georgia, USA (1995)

Checkland, P.: Systems Thinking, Systems Practice. John Wiley, Chichester (1981)

Conti, A., Gaule, P.: The CEMI Survey of University Technology Transfer Offices in Europe, Lausanne, Switzerland. Ėcole Polytechnique Fédérale de Lausanne (2008)

CMT - College du Management de la Technologie, The economics of Technology Transfer Offices (TTOs) (Updated 2009)

`http://cemi.epfl.ch/page33774.html` (Accessed June 18, 2009)

D'Este, P., Patel, P.: University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? Research Policy 36, 1295–1313 (2007)

Editorial, Is my practice evidence-based? British Medical Journal 313, 957–958 (1996)

Geuna, A., Muscio, A.: The governance of University knowledge transfer. In: SPRU Electronic Working Paper Series, University of Sussex, vol. 173. SPRU - Science and Technology Policy Research, Brighton (2008)

Grant, E.B., Gregory, M.J.: Tacit knowledge, the life cycle and international manufacturing transfer. Technology Analysis & Strategic Management 9(2), 149–161 (1997)

Guldbrandsen, M., Smeby, J.C.: Industry funding and university professors' research performance. Research Policy 34, 932–950 (2005)

Murray, F.: The role of academic inventors in entrepreneurial firms: Sharing the laboratory life. Research Policy 33, 643–659 (2004)

Trinder, L., Reynolds, S. (eds.): Evidence-Based Practice: A Critical Appraisal. Oxford-Wiley-Blackwell (2000)

Oakley, B., Owen, K.: Alvey. Britain's Strategic Computing Initiative. MIT Press, Cambridge (1990)

Siegel, D.S., Wright, M., Lockett, A.: The rise of entrepreneurial activity at universities: Organizational and societal implications. Industrial & Corporate Change 16(4), 489–504 (2007)

Siegel, D.S., Waldman, D.A., Atwater, L.E., Lonk, A.N.: Commercial knowledge transfers from universities to firms: Improving the effectiveness of university-industry collaboration. Journal of High Technology Management Research 14(1), 111–133 (2003)

Thompson, S.B.N.: A system for rapidly converting quadriceps contraction to a digital signal for use in microcomputer-oriented muscle therapy and stroke patient assessment schedules. Computers in Biology & Medicine: An International Journal 17(2), 117–125 (1987a)

Thompson, S.B.N.: A microcomputer-feedback system for improving control of incompletely innervated leg muscle in adult cerebrovascular accident patients. British Journal of Occupational Therapy 50(5), 161–166 (1987b)

Thompson, S.B.N.: Leg-injured patients switch on to rehabilitation. Therapy Weekly 13(28), 7 (1987c)

Thompson, S.B.N.: Working in stroke rehabilitation: Trends for clinical neuropsychology for the next century. Journal of Cognitive Rehabilitation 16(3), 6–11 (1998)

Thompson, S.B.N.: Rehabilitation of Cognitive and Emotional Problems. In: Fawcus, R. (ed.) Stroke Rehabilitation: A Collaborative Approach, pp. 147–159. Blackwell, Oxford (1999)

Thompson, S.B.N., Coleman, M.J.: A quantitative assessment of neuromuscular function for use with unilateral cerebrovascular accident patients. International Journal of Rehabilitation Research 10(3), 312–316 (1987)

Thompson, S.B.N., Coleman, M.J.: Occupational therapists' prognoses of their patients: Findings of a British national survey of stroke. International Journal of Rehabilitation Research 11(3), 275–279 (1988)

Thompson, S.B.N., Coleman, M.J.: An interative microcomputer-system for the assessment and prognosis of stroke patients. Journal of Microcomputer Applications 12(1), 33–40 (1989)

Thompson, S.B.N., Coleman, M.J., Yates, J.: Visual feedback as a prognostic tool. Journal of Microcomputer Applications 9(3), 215–221 (1986)

Thompson, S.B.N., Morgan, M.: Occupational Therapy for Stroke Rehabilitation. Chapman & Hall, London (1996)

Knowledge Transfer for Supporting the Organizational Evolution of SMEs: A Case Study

Dominique Renaud[1], Philippe Bouché[1], Nathalie Gartiser[1], Cecilia Zanni-Merk[1], and Henri-Pierre Michaud[2]

[1] LGECO – INSA de Strasbourg - 24 bd de la Victoire – 67084 Strasbourg Cedex, France
e-mail: {dominique.renaud,philippe.bouche,nathalie.gartiser, cecilia.zanni-merk}@insa-strasbourg.fr
[2] AEM Conseil - 3 rue de l'Ill – 67116 Reichstett, France
e-mail: hp.michaud@free.fr

Abstract. This article describes the research project MAEOS that has been launched six months ago for a three year duration. The goal of this project is the modelling of the support of the evolution of Small and Medium Enterprises (SMEs). The developed models will constitute the foundations of a knowledge based system that will permit consultants to improve the effectiveness of their missions thanks to the implementation of theoretical and practical domain knowledge.

1 Introduction

One of the major difficulties encountered by the smallest companies, especially today, in a crisis context, is how to manage their evolution. This issue needs the capacity to, not only, perform a global analysis of the whole of its aspects (economical, production, organization, human resources, sales …) but also to have a sufficient stand back to see this analysis in the perspective of that evolution. Mastery of change becomes a key to success for many firms facing to strong competition.

Very often, the SMEs getting involved in this approach look for the help of consultancy services. In this context, there is a recurrent question that arises: how to access existing knowledge to, on the one hand, allow diagnosis of the SME and, on the other hand, think about its evolution.

Here, there are several important aspects regarding knowledge transfer. The main problem is that the volume of knowledge, both theoretical and "expert", is huge and sometimes, much more detailed than needed. We face a double issue about knowledge capitalization: structuring for managing the large quantities of knowledge and organizing into a hierarchy for permitting different access levels.

This knowledge transfer may lead to two different types of results. Firstly, it may allow the consultant and the company to more easily put typical solutions in practice. These solutions may be already known, but they might have not been yet

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 293–302.
springerlink.com

implemented in the company. This fact will allow the company to go further in its evolution, integrating innovation in this way, even if this innovation is minor because it only concerns the company itself. Secondly, the knowledge transfer led by MAEOS and the automatic reasoning that is integrated in it might allow the consultant to propose original solutions, generating in this way high level innovations, because they are radically new.

This article is structured as follows: In first place, we present the project along with several issues regarding the manipulation of knowledge and, in particular, with the ontological framework of our development. Afterwards, we discuss knowledge capitalization and we develop an example. Finally, we present our conclusions.

2 The Project

MAEOS is a project about the modelling of the support to the organizational and strategic development of SMEs. The main objective of MAEOS is to improve the efficiency and performance of business advice to SMEs.

To achieve this objective, a multidisciplinary team was created. Three main research areas are represented: artificial intelligence, software engineering and management sciences. This work aims at establishing a set of methods and software tools for analysis and diagnosis of SMEs. The software tools have to be able to evolve according to the state of the art about SMEs and, in particular, their administrative or legal environments. In addition, they must also be able to reflect the richness and contradictions that are inherent to the models coming from management sciences. Finally, they must be able to transfer the used knowledge to the consultants.

Although closely related, these constraints can be considered according to three aspects: the manipulation of such knowledge, the use of heterogeneous knowledge and the transfer of that knowledge.

2.1 Handling Heterogeneous Knowledge

Unlike current trends, which are to represent knowledge in a homogeneous knowledge base covering the domain of a problem, our choice is different. It is to keep to a maximum the plurality of each knowledge base with their fields of interest, constraints and richness. The interest and the difficulty of this part of the project are to combine a large variety of sources and origins of knowledge around SMEs topics.

The targeted knowledge is separated into two kinds of expertise. On the one hand, the theoretical knowledge in the area of change in SMEs (organizational, strategic…) is used as core models and on the other hand, expert knowledge accumulated during practice is used as complementary knowledge. Knowledge bases, in progress, are designed to cover a significant portion of aspects relating to organization, production and managerial behaviours of SMEs.

2.2 Using Heterogeneous Knowledge

The operation process that has been chosen is similar to that of a panel of experts. Each expert has an area of knowledge and a set of skills. He examines aspects of the business related to his area of expertise. Once the study is completed, his conclusions are shared with other experts. Finally, an analysis and diagnostic report is created.

In its implementation, the system is an ecosystem of reactive agents (Fig. 1). It consists in several knowledge bases on areas relating to business management which are attached to software agents with the ability to exploit their content. The agents use three kinds of knowledge bases (KB). The first one is a rule-based KB containing academic knowledge. The second one contains cases related to the socioeconomic context of SMEs and some specific cases already studied. And the third one consists in a set mapping rules among the different used ontologies.

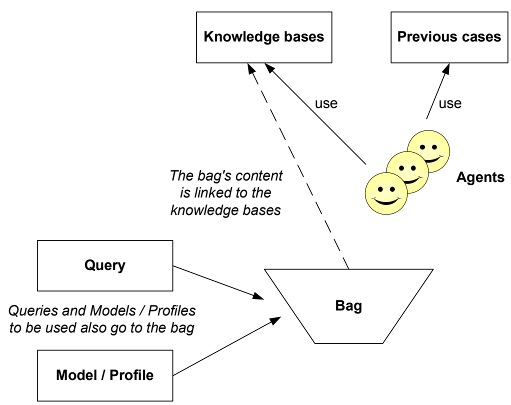


Fig. 1 The multi-agent system

At present, the ecosystem is not complete. Indeed, no direct communication among agents exists. All exchanges are made through a common bag. An agent is associated with a particular knowledge base. Therefore, all agents are characterized by a knowledge domain, a collection of facts and/or rules and a set of metadata. Each agent picks information up in the common bag. It accomplishes its deduction tasks. At the end, it adds the results to the bag. The triggering of an agent is made by a set of data corresponding to the characteristics of its knowledge base. The process is considered as finished when the agents have nothing new to add to the common bag. At the end, a series of post-processing operations aggregate the entire contents of the bag. This is to provide concise results that are close to the context of the subject of study.

2.3 Transferring Heterogeneous Knowledge

The main characteristic of this project is the use of large quantities of heterogeneous knowledge. It is very complicated and time consuming to transmit all this knowledge to a consultant. The proposed approach is to create a new knowledge base to present the result of the analysis to the consultant in a concise way. This new knowledge base is built upon theoretical and practical knowledge already present in the system and includes the deductions coming from the multi-agent system. This presentation focuses on the aggregation of results provided by that multi-agent system. With this goal in mind, post-processing operations try to combine all the homogeneous results and point differences out (Renaud, 2009). The explanation of the results is given from the current context analysis of the SME being processed. These explanations (that is, knowledge about the current case and the theoretical foundations of the deductions that have been made) will permit the consultant to learn new skills from each case study.

The implementation of these three aspects requires having a computable and structured representation of knowledge. This representation must allow the handling and use of that knowledge in a formal way. To do this, the use of ontologies is the best possible solution (Milton, 2007).

2.4 Ontological Framework of Our Development

An ontology is a formal explicit description of concepts in a domain of discourse and includes classes (sometimes called concepts), properties of each concept describing various features and attributes of the concept or slots (sometimes called roles or properties), and restrictions on slots, called facets (sometimes called role restrictions). An ontology together with a set of individual instances of classes constitutes a knowledge base (Noy, 2001).

An ontological study was conducted to provide the theoretical bases necessary for the development. Several ontologies have been studied.

Our main sources were the ontology MASON (Lemaignan, 2006), TOVE (Fox, 1992, 1998) and ENTERPRISE (Uschold, 1998). Some parts of specific ontologies have been also considered. These ontologies cover different areas such as Professional Learning and Competencies with the ontology of FZI-Karlsruhe (Schmidt, 2007), organization modeling with UEML-1 (Berio, 2005), or Service Oriented Architectures with the SOA Open Group ontology (Open Group, 2009); among others.

Beyond the utilization of existing ontologies, we develop our own ones about certain relevant fields for our SME context (organization, quality, production, innovation …). Nevertheless, we risk to be confronted to a double issue about contradictions at knowledge level: contradictions among knowledge sources and contradictions within a knowledge source. It is because of these issues that we have decided to develop separate ontologies and to separately process these two sources of contradictions.

In first place, we have developed an ontology on the organization models based on the main works of (Mintzberg, 1979). This ontology integrates the concepts that describe the structure and models of companies, the relationships among concepts and the restrictions to those concepts according to the company characteristics (its size, for example, that is relevant for this project). We have made the choice of using this source because it is a clear reference in the organization theory field, at least at the concept level. The works of this author have been widely quoted, commented and refined.

Other works of this author (Mintzberg, 1989) will complete this ontology.

3 Knowledge Capitalization

The innovating nature of our proposal is the fact that the software tool will be based on the development of a conceptual model of the knowledge to be used. This fact implies a capitalization and a structuring of existing knowledge in the field of management of SMEs evolution. It will be about identifying the relevant knowledge in existing scientific literature and about structuring it to permit its use in real situations. The choice of the necessary knowledge for our model will concern not only existing scientific knowledge but also the practical knowledge of the consultant.

Furthermore, there is a question about the updating of the system regarding knowledge. This will be done through an important characteristic of the software tool; it has to be "self improving". In this way, along with its utilization, the new necessary knowledge will come feed the model.

The main goal is not only to gather new knowledge for the consultant, but also to develop another kind of skill, that is to put new knowledge into practice in real situations: it is not about transferring "encyclopedic" knowledge to the consultant and to rely on his "art" to find it useful. It is about providing him with tools and methods to facilitate his access to pertinent knowledge when he needs it, and in this way, to increase his own competence.

Furthermore, our goal is to feed the conceptual model with an important quantity of pertinent knowledge, to reduce to a minimum the research and acquisition time for the consultant.

The pieces of knowledge that will be put in practice are of different nature: there will be theoretical knowledge about management of evolution in SMEs, there will be practical knowledge about the case studies previously performed by the consultant, and, if possible, we will include the knowledge about the results of the application of the suggestions made by the consultant in previous cases.

Fig. 2 describes the development phases of the MAEOS project. The idea is to describe the development and utilisation steps of the software tool. The notation we use in Fig. 2 comes from (Schreiber, 2000):

- Ellipses represent the activities or tasks
- Rectangles represent dynamic knowledge sources that are inputs or outputs of the activities.
- Two bars represent static knowledge sources, which cannot be modified. Therefore, these static sources are always inputs to the tasks.

The three main steps in the project will be described in the following sub-sections.

3.1 The Development Phase

This phase includes two sub-phases.

Knowledge bases are built taking into consideration scientific literature in the field of change in SMEs, existing models (for example, ontologies for enterprise modelling) and case studies already performed by the consultant.

The output of this sub phase will be the knowledge base that will be the core of the software tool. This knowledge base will be also at the base of the development of the inference engine of our tool.

3.2 The Utilization Phase

This phase includes several sub-phases.

The study of new cases will allow the extraction of pertinent information about the reality of SMEs (problems, remarks about its operation, etc.). These pieces of information will be extracted according to the knowledge base in the software.

Once these pieces of information gathered, the software tool will be able to launch the inference engine and deduce other facts according to that information. These deductions will be showed to the consultant that will have the choice to complete them (according to his own experience) or not.

These deductions and the suggestions that the consultant may make to improve the functioning of the company are delivered to the responsible that will have the choice to put them in practice or not.

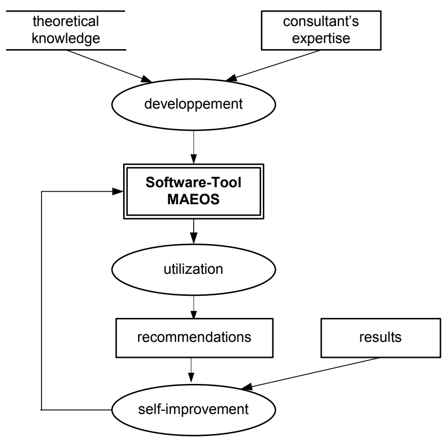


Fig. 2 The deployment of the MAEOS project

3.3 The Self-improvement Phase

As we have stated before, the responsible of the SME has the choice of putting the recommendations of the consultant into practice. If it has been made, there will be the possibility of comparing those recommendations and the corresponding results. The confirmations or differences that might be remarked will be used to update the knowledge base.

Apart from that, other updates to the knowledge base include new scientific literature or new case studies.

The MAEOS project fundamentally differentiates from other approaches because of the different nature of the pieces of knowledge to manipulate and of the goal of the software tool. The idea is not to build a knowledge server to manage a corporate memory (Van Heijst, 1996) (Nagendra, 1996), but to develop a framework for theoretical and knowledge structuring about strategic analysis of evolution in SMEs.

The next section introduces a small example of the outputs that may be expected from our software tool.

4 An Example

The first task of the consultant in the company is to have an overview of its situation. This overview is obtained through one or several interviews.

Our industrial partner has given us access to these interviews. After reading them, we have identified a set of concepts associated to one of our ontologies. Initially, this step is done manually, but when the knowledge based system will be achieved, the consultant will have to inform the identified concepts to the system.

For a particular company, the initial situation was the following (it is just a short description of the case study): It is about a very small company whose executive director has all the responsibilities. He concentrates most of the power and, therefore, he has too many tasks to accomplish. These facts have led him to recruit a new sales and marketing person. Other point in this initial situation was a future relocation of the enterprise.

With these elements in mind, we have identified some concepts evoked in the Mintzberg ontology (Mintzberg, 1979): `Horizontal_decentralization` and `Analyst`, among others. The instances of these concepts for a particular case study will be the inputs to the knowledge based system.

As already stated, an ontology includes a set of concepts permitting to retain a certain point of view for a particular description, a set of relationships among concepts and, eventually, the restrictions associated to the concepts.

The concepts instantiated above permitted the identification of the relationships and rules in the ontology that may be launched to predict plausible evolution thanks to the inference engine of the knowledge-based system. Fig. 3 shows some of those rules and relationships.

Progressing in this way, and thanks to the identified rules and relationships among instances, for the concerned company it was deduced that:

- The arrival of the new analyst induces more standardization in the company (first relationship). Standardization also results from the relocation of the enterprise.
- An increase in standardization implies, as a consequence, an increase in the unit size (rule) which is the cause of a transformation of the informal communication system (second relationship).

- From horizontal decentralization we can directly conclude about the transformation of the informal communication system (third relationship).

Even if this example remains quite simple, the interest of the knowledge based system will be the use of different ontologies to propose new solutions to the consultant to assist him in his mission.

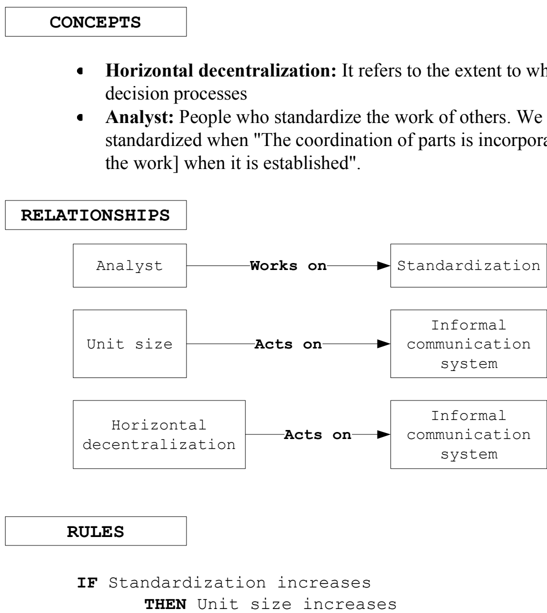


Fig. 3 Part of the Mintzberg ontology

5 Conclusions

In this article we have presented our first results about a knowledge-based system to assist consultants in their missions of analysis and diagnosis of SMEs. This system consists in a set of knowledge bases whose contents are heterogeneous and this fact raises two sorts of problems.

The first one is focused on the management of knowledge structures and backgrounds. It takes the form of complex cycle phases including acquisition, use and maintenance. The second one is focused on the transfer of knowledge to the consultant. This knowledge should respond to issues that are specific to SMEs. Moreover, the expectation of the consultant is to obtain innovative solutions with several alternatives coming from the system. Also, as he must be able to explain his recommendations to his client, he needs to understand the suggestions and analysis provided by the system.

To solve these problems, our approach is to split the different fields of knowledge into smaller modular and homogeneous bases. This approach is supported by the exclusive use of formal ontologies. This point is motivated by the possibilities of manipulation of knowledge and a strict framework imposed by this type of ontology. In this way, we hope to combine the advantages of rigorous knowledge manipulation, adaptability to particular cases and readability of the results.

Once the software tool will be finished, it will permit two levels of knowledge capitalization. On the one hand, the consultant will see his competence improve by the use of it and by the access to different knowledge sources. On the other hand, the SME being coached by the consultant will see its performance improve.

We hope to have two different kinds of results: firstly, to give the possibility to the consultant and to the company to access to typical known solutions; secondly, to help consultants to develop innovative solutions by means of a more performing access to existing knowledge.

References

Berio, G., Frank-Walter, J., Mertins, K.: Common Enterprise Modelling Framework for Distributed Organisations. In: Proc. of the 16th IFAC World Congress, Prague, Czech Republic (2005)

Fox, M., Grüninger, M.: Enterprise Modeling. AI Magazine, 109–121 (1998)

Fox, M.: The TOVE project: A Commonsense Model of the Enterprise. In: Belli, F., Radermacher, F.J. (eds.) IEA/AIE 1992. LNCS, vol. 604, pp. 25–34. Springer, Heidelberg (1992)

Lemaignan, S., Siadat, A., Dantan, J.-Y., Semenenko, A.: MASON: A proposal for an Ontology of Manufacturing Domain. In: IEEE Workshop on Distributed Intelligent Systems, Collective Intelligence and Its Applications. DIS 2006, pp. 15–16, 195–200 (2006)

Milton, N.R.: Knowledge Acquisition In Practice: A Step-By-Step Guide. Springer, London (2007)

Mintzberg, H.: The Structuring of Organizations. Prentice-Hall, Englewood Cliffs (1979)

Negrenda Prasad, M.V.N., Plaza, E.: Corporate Memories as Distributed Case Libraries. In: Gaines, B., Musen, M. (eds.) Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW 1996), 40-1/40-19 (1996)

Mintzberg, H.: Mintzberg on Management: Inside Our Strange World of Organizations. Simon & Schuster Inc., United States of America (1989)

Noy, N.F., McGuinness, D.L.: Ontology Development 101: A Guide to Creating your First Ontology (2001), http://www.ksl.stanford.edu/people/dlm/papers/ontology101/ontology101-noy-mcguinness.html

Renaud, D., Zanni-Merk, C., Rousselot, F.: A Compound Strategy for Ontologies Combining. In: Proc. of KEOD 2009 International conference on knowledge engineering and ontology development, Madeira, Portugal (2009)

Schmidt, A., Kunzmann, K.: Sustainable Competency-Oriented Human Resource Development with Ontology-Based Competency Catalogs. In: Cunningham, M., Cunningham, P. (eds.) eChallenges (2007)

Schreiber, G., Hakkermans, H., Anjewierden, A., de Hoog, R., Shadbolt, N., Van de Velde, W., Wielinga, B.: Knowledge Engineering and Management - The CommonKADS Methodology. MIT Press, Cambridge (2000)

Uschold, M., King, M., Moralee, S., Zorgios, Y.: The Enterprise Ontology. The Knowledge Engineering Review 13, 31–89 (1998)

Van Heijst, G., Van der Spek, R., Kruizinga, E.: Organizing Corporate Memories. In: Gaines, B., Musen, M. (eds.) Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW 1996), pp. 42–1/42–17 (1996)

Knowledge-Based New Product Development through Knowledge Transfer and Knowledge Innovation

Ming-Chang Lee

Department of Information Management, Fooyin University, Taiwan
e-mail: Ming_li@mail2000.com.tw

Abstract. This paper develops and presents the concept of knowledge-based new product development in an effort to explain the role of knowledge in new product development and the process of innovation management. Due to advances in science and technology and the rapid changes in the market, a product's life cycle has become much shorter than it was before. A new product strategy is an important activity that helps enterprise to survive and make continuous improvements. Most enterprises have placed great emphasis on shortening the time for a new product coming into the market.

The aim of this paper provides the integration of knowledge management value and innovation management to introduces a strategic management approach towards knowledge innovation as a source of sustainable competitive advantage

1 Introduction

Knowledge transfer in the fields of organizational development and organizational learning is the practical problem of transferring knowledge from one part of the organization to another organization (or all other) parts of the organization. Like Knowledge Management, Knowledge transfer seeks to organize, create, capture or distribute knowledge and ensure its availability for future users. Knowledge transfer is more complex because (1) knowledge resides in organizational members, tools, tasks, and their sub-networks (Argote and Ingram, 2000) and (2) much knowledge in organizations is tacit or hard to articulate (Nonaka and Takeuchi, 1995). Knowledge management is one of critical assets to leverage when pursuing enterprise competitive advantage (Lee and Choi, 2003; Sharkie, 2003)). Nonaka and Takeuchi (1995) proposed that knowledge creation was generated by the interaction of tacit knowledge and explicit knowledge. Delong and Fahey (2000) developed a useful framework to classify knowledge, which distinguished among human, social, and structured of knowledge. Many organizations are now engaging in KM in order to leverage both within their

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 303–320.
springerlink.com

organization and externally to their customers and suppliers (Rubinstein-Montano et al., 2001).

Amidon (1997) has aptly described "knowledge innovation" as the creation, evolution, exchange and application of new ideas into marketable goods and services, leading to the success of enterprise, the vitality of a nation's economy and the advancement of society. Therefore, Knowledge innovation is a process which people use the past knowledge to create new knowledge by some necessary technology channels and creative thinking activity of brain. It is active to change knowledge amount expansion, quality improvement, knowledge extension, depth, and originality.

A new product development (NPD) strategy is an important activity that helps enterprise to survive and make continue improvements. Most enterprises have now placed great emphasis on shortening the time for a new product coming into market. Firms have adopted knowledge management (KM) and innovation management (IM) method and NPD strategy.

This paper provides the integration of knowledge management value and innovation management to introduce a strategic management approach towards knowledge innovation as a source of sustainable competitive advantage. This paper applies the current knowledge and knowledge innovation to invent new product and let this kind of action more efficient. It maintains the new product can be more useful and acceptable in the market. The aim of this paper is to explore the correlation among KM activity, IM, and NPD, NPD strategy and performance (Hansen, et al., 1999; Von Krog et al., 2000).

2 Knowledge Management Value Chain

The KVC is a basic template for the value architecture of any knowledge-intensive business process. As the missing link between enterprise intelligence and business strategy, the KVC draws on Business Process Optimization techniques to increase the value added by business information. The KVC starts with the premise that "Intelligence is not a cost, it's an investment." The KVC model helps you maximize the return on that investment by optimizing the efficiency and effectiveness of organizational intelligence and other knowledge processes.

Shin et al.., (2000) purpose that KM value chain reflects sociology of knowledge. Tsoukas (1996) indicates that individual knowledge is built up by social practices engaged in by the individual; therefore the two kinds of knowledge with individual knowledge. It is essential that the KM value chain should to explain to some degree social knowledge and its interactions with individual knowledge. It is essential that the KM value chain should be strategically driven in order to realize the objectives of an organization, and resulting in the continuously cycling process.

KM activities can be through of as a structured coordination for managing knowledge effectively. Typically, knowledge processes include activities such as creation, diffusion, transfer, and application. Whereas knowledge processes represent the basic operations of knowledge, enablers provide the infrastructure necessary for the organization to increase the efficiency of knowledge processes.

3 Innovation Management

Innovation management (IM) - which is a field of discipline that deals primarily with issue relating to how the innovation process could be managed effectively, has attracted much attention too (Goh, 2004; Harkema and Browrys, 2002). With innovations as the mainstay of today's business, IM is now an organization's core function.

The innovation value chain (IVC) is a thinking tool which can be used to define those enterprises involved in innovation activities such as product development. Each link in the chain needs to add value to innovation. The IVC helps think through the often-complex relationships in product development and look for improvements in relationships (with suppliers, customers, partners and competitors) and partnerships (see Table 1). Some existing theories stress the technological development, such as Market Adoption Model, The Product/Service life Cycle, and Technology Readiness Level.

Table 1 The Innovation Value chain

Ideation	Project Selection	Development	Commercialization
-New Product and technology ideals - New business concepts and opportunities -Consumer insights -Tread analysis and anticipation - New-to-the world and extensions of existing ideals	-Strategy and new product linkage -Governances of new initiative - Tracking and definition - project approval decision making processes - use of advanced valuation methodologies	-Disciplined and effective stage/gate process - Time to market - Bottleneck elimination and identification of project 'congestion" -Parallel planning of work steps. - Resource allocation	-Marketing and investment - Consumer profiling and segmentation - Competitive resources and timing - Advertising and promotion decision making - Product tracking-

Source: Booz Allen Hamilton (Ferry, 2004).

(1) Market adoption model (Rogers, 1976)

Rogers' suggests a total of five categories of adopters in order to standardize the usage of adopter categories in diffusion research. It should be noted that the adoption of an innovation follows an S curve when plotted over a length of time.

The categories of adopters are: innovators, early adopters, early majority, late majority, and laggards.

Innovators: Innovators are the first individuals to adopt an innovation. Innovators are willing to take risks, youngest in age, have the highest social class, have great financial lucidity, very social and have closest contact to scientific sources and interaction with other innovators.

Early Adopters: This is second fastest category of individuals who adopt an innovation. These individuals have the highest degree of opinion leadership among the other adopter categories. Early adopters are typically younger in age, have a higher social status, have more financial lucidity, advanced education, and are more socially forward than late adopters.

Early Majority: Individuals in this category adopt an innovation after a varying degree of time. This time of adoption is significantly longer than the innovators and early adopters. Early Majority tend to be slower in the adoption process, have above average social status, contact with early adopters, and show some opinion leadership.

Late Majority: Individuals in this category will adopt an innovation after the average member of the society. These individuals approach an innovation with a high degree of skepticism and the majority of society has to have adopted the innovation. Late Majority are typically skeptical about an innovation, have below average social status, very little financial lucidity, in contact with others in late majority and early majority, very little opinion leadership.

Laggards: Individuals in this category are the last to adopt an innovation. Unlike some of the previous categories, individuals in this category show little to no opinion leadership. These individuals typically have an aversion to change-agents and tend to be advanced in age. Laggards typically tend to be focused on "traditions", have lowest social status, lowest financial fluidity, oldest of all other adopters, in contact with only family and close friends, very little to no opinion leadership. The diffusion process is showed as Figure 1.

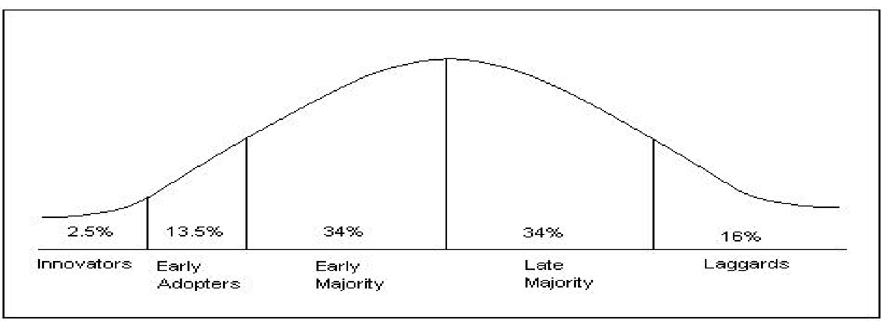


Fig. 1 The diffusion Process Source: Rogers (1976)

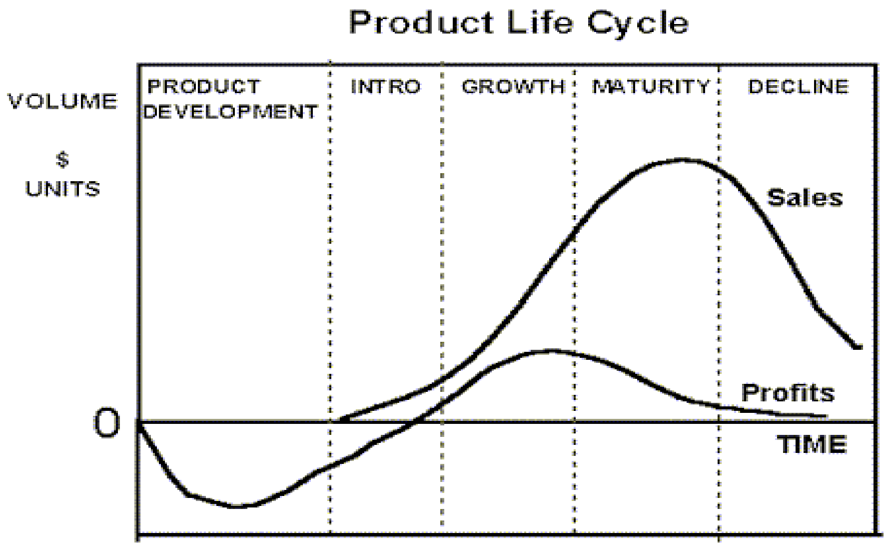


Fig. 2 Product life cycle

This bell-shaped curve describes the role that different segments of the population can play in the knowledge transfer process. t can also be helpful in describing ways in which the knowledge transfer process can be improved.

(2) The Product/Service life cycle

The Product/Service life cycle: The market adoption model which was developed based on the DOI theory (Diffusion of innovations) (Rogers, 1995), and Product /Service Life Cycle (Beacham, 2006). The lifecycle model suggests that market adoption reflects a bell curve that tracks to customer/customer adoption of a new technology, product and services. The life cycle, as Figure 2 portrays, can be described by a S-curve. From the perspective of profit with respect to time, the curve can generally be classified into four stages as follows:

(1) Market introduction: The market introduction of products begins when a new and innovative product passes quality and function tests, and is introduced to customers. No products already in the market share the functions or appearance of the product, and thus the market is uncontested.

(2) Growth: When the innovative products are marketed and gradually approved by customers, profits also increase. If the products have superior functions and technology to existing products, and if this superiority is confirmed by market testing and use, the products and their corresponding technologies will replace existing products. However, if customers do not appreciate the innovations, the products will quickly vanish from the market. When a product is successful, more and more enterprises will begin to develop similar products and technology. Meanwhile, the original enterprises, which

have been involved in researching such products since their beginnings, will seek to constantly improve their products according to the requirements of customers to enhance their competitiveness.

(3) Maturity: Reliability and quality of products peak during this period. Enterprises also profit enormously, but profit growth begins to slow. A few brands of products dominate the market.

(4) Decline: A new generation of products appears. Most enterprises' products lose their competitiveness since the appearance of mainstream brands. Price competition characterizes this period. Four stages' key issues and activities are denotes as Table 2.

Table 2 Four stages' key issues and activities of product life cycle

Time	**Market introduction**	**Growth**	**Maturity:**	**Decline:**
Key issues	Establish customer need	Supply Feast/Famine	Margin erosion	Replacements
Activities	-Launch -Promotion/marketing -Model improvement -Cash neutral	-Standardization -Process improvement -Reinvestment -Cash generating	-Cost reduction -Economy of scale -Novel variations -Cast generating	-Declining cash -Exit plan

(3) Technology Readiness Level

Technology Readiness Level (TRL) is a measure used by some United States government agencies and many of the world's major companies (and agencies) to assess the maturity of evolving technologies (materials, components, devices, etc.) prior to incorporating that technology into a system or subsystem. The most common definitions are those used by the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA). Technology Readiness Levels were originally developed by NASA in the 1980s. The original definitions only included seven levels. These were later expanded to nine levels. Table 3 is denoted as Technology Readiness Levels.

The primary purpose of using Technology Readiness Levels is to help management in making decisions concerning the development and transitioning of technology. Advantages include:

- Provides a common understanding of technology status
- Risk management
- Used to make decisions concerning technology funding
- Used to make decisions concerning transition of technology

Disadvantages include:

- More reporting, paperwork, reviews
- Relatively new, takes time to influence the system

Table 3 Technology Readiness Levels in the Department of Defense (DOD)

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

(Source: DOD (2006), Defense Acquisition Guidebook).

4 Knowledge Innovation

The Knowledge Innovation is creation, evolution, exchange and application of new ideas into marketable goods and services, leading to the success of an enterprise, the vitality of a nation's economy and the advancement of society. Knowledge Innovation embodies the concept that innovation is the one competence needed for the future. It addresses the all the fundamental management dimensions in the process of innovation - the creation and conversion of ideas into viable commercial products in addition to building a foundation for future sustainable growth.

There are five core concepts that distinguish knowledge innovation from other knowledge and innovation approaches:

- Innovation Value System (not value chain) - value chain thinking is linear and static. The innovation value system is dynamic and shows all the interdependent relationships that are need to be developed for successful innovation.
- Strategic Business Network (not Strategic Business Units) - strategic business unit management tends to create isolated islands of knowledge. The Strategic Business Network encourages the flow of knowledge between partners, customers, suppliers, research organizations and other stakeholders, including competitors, in the innovation process.
- Collaborative (not Competitive) Advantage - Competitive strategies create win-lose scenarios, often competing for a share of the same pie.
- Collaborative strategies encourage win-win situations through symbiotic relationships. Knowledge grows and the pie gets bigger for all.
- Customer Success (not Satisfaction) - Customer satisfaction meets today's articulated need. A focus on the success of your customer helps identify those future unarticulated needs, the source of growth and future success.

There are two tools for creating innovation. (1) System Readiness level: System Readiness level will be defined by the current state of development of a system in relation to the United States Department of Defense's (DoD) Phases of Development for the Life Cycle Management Framework. (2) 12 Dimensions of business: The innovation radar can be a strategic brainstorming tool, helping to identify opportunities in consideration of all aspects of the business, and to prioritize areas for focus. The tool can also help identify potentially dysfunctional approaches to innovation.

(1) System Readiness level

System Readiness level has five phases (readiness level): (1) concept refinement, (2) technology development, (3) system development & demonstration, (4) operation & support. Table 4 is denoted that the definition of system readiness level.

Table 4 The definition of system readiness level

SRL	Name	Definition
5	Operations & Support	Execute a support program that meets operational support performance requirements and sustains the system in the most cost-effective manor over its total life cycle.
4	Production & Development	Achieve operational capability that satisfies mission needs.
3	System Development & Demonstration	Develop a system or increment of capability; reduce integration and manufacturing risk; ensure operational supportability; reduce logistics footprint; implement human systems integration; design for reducibility; ensure affordability and production of critical program information; and demonstrate system integration, interoperability, safety, and utility.
2	Technology Development	Reduce technology risks and determine appropriate set of technologies to integrate into full system.
1	Concept Refinement	Refine initial concept. Develop system/technology development strategy

(2) 12 Dimensions of business (Sawhney et al., 2006)

Although innovation is currently amongst the top-issues of many corporations, many executives have a wrong, too narrow view of it. They see innovation as synonymous with New Product Development or Traditional R&D. To clarify this error, Sawhney et al. (2006) in the MIT Sloan Management Review (Spring 2006) introduce their **Innovation Radar**.

The innovation radar displays the 12 dimensions of business innovation, anchored by the offerings a company creates, the customer it serves, the process it employs and the points of presence it uses to take its offering to market. Table 5 is denoted as 12 Dimensions of business.

Table 5 The 12 dimensions of business innovation

Dimension	Definition	Example
Offering	Develop innovative new products or service	- Apple ipod music player and iTunes music service
Platform	Use common components or building blocks to create derivative	-General Motors on Star telemetric platform - Display animated movies
Solution	Create integrated and customer offerings that solve end-to-end customer problems.	-UPS logistics service supply chain solution -DuPont building innovations for construction
Customers	Discover unmet customer needs or identify underserved customer segments.	-Enterprise Rent-A-Car focus on replacement car renters -Green Mountain Energy focus on “green power”
Customer Experience	Redesign customer interactions across all touch points and all moments of contact.	-Washington-Mutual Occasion retail banking concept -Cabala’s “store as entertainment experience” concept

Table 5 (*continued*)

Value Capture	Redefine how company gets paid or create innovative new revenue streams.	-Google paid search -Blockbuster revenue-sharing with movie distributors
Processes	Redesign core operating processes to improve efficiency and effectiveness	-Toyota production system for operations -General Electric Design for Six Sigma (DFSS)
Organization	Chang form, function or activity scope of the time	-Cisco partner-centric networked virtual organization -Procter & Gamble front-back hybrid organization for customer focus
Supply Chain	Think differently about sourcing and fulfillment	-Moen ProjectNet for collaborative design with suppliers -General Motors Celta use of integrated supply and online sales
Presence	Create new distribution channels or innovation points of presence including the places where offering can be bought or used by customers.	-Starbucks music CD sales in coffee stores -Diebold remote teller system for banking
Networking	Create network-centric intelligent and integrated offerings.	-Otis remote elevator monitoring service - Department of Defense Network Centric Warfare
Brand	Leverage a brand into new domains.	-Virgin Group “branded venture capital” -Yahoo as a lifestyle brand

5 New Product Development

5.1 NPD Strategies

In business and engineering, new product development (NPD) is the term used to describe the complete process of bringing a new product or service to market. There are two parallel paths involved in the NPD process: one involves the idea generation, product design, and detail engineering; the other involves market research and marketing analysis. Companies typically see new product development as the first stage in generating and commercializing new products within the overall strategic process of product life cycle management used to maintain or grow their market share.

Cooper (1984 a, b) proposed the NPD should have four variables while we concerning a new product development strategy. (1) The enterprise to a new product: This includes creating a new product, developing a better product for meeting the customer’s demand than that of competitors, and product concentration and differentiation. (2) Market characteristic adopted by the new product which contain the characteristics for a new market, customers, competitors and new sale channels. (3) The enterprise's technological orientation and commitment, which includes the percentage of research and development (R&D) expense to sales amount, company's R&D orientation. (4) Technological characteristic adopted by the new product, which includes more advanced and complicated technologies, closely matched with the company's R&D resources, technical maturity and concentration.

Veryzer (1998) point out two important aspects: technological capability and product capability. Technological capability means that a product must be made using a technology beyond the current company technology level. Product capability represents the benefit of product recognized or experienced by customers. Clark et al. (1987) viewed the new product development process as information processing. There are four steps to involve during NPD: (1) Conception generation, converting the information required by the customer into a conception statement; (2) Product planning, development performance, cost, form, and other objectives per the product conception; (3) Product engineering, converting the product objectives into detailed drawings; (4) manufacturing engineering, designing the work flow, tools equipment, procedures for part processing, per the engineering drawings.

Technological or knowledge transfer and linkages within the company, the interface and Information sharing among group members especially R&D, marketing and manufacturing are very important for the success of NPD. NPD requires knowledge creation and searching, and can be organized in different ways (Mild and Taudes, 2007). Successful NPD depends on the ability to understand technical and market knowledge embodied in existing product, and the adaptation of this knowledge to support NPD (Aoshima, 2002).

In our current research, we are investigating how companies can use the innovation radar to construct a strategic approach to innovation. Specifically, the radar could help a firm determine how its current innovation strategy stacks up against its competitors. Using the information, the company could then identify opportunities and prioritize on which dimensions to focus its efforts.

5.2 The Process of NPD

1. **Idea Generation** is often called the "fuzzy front end" of the NPD process
   - Ideas for new products can be obtained from basic research using a SWOT analysis (Strengths, Weaknesses, Opportunities & Threats), Market and consumer trends, company's R&D department, competitors, focus groups, employees, salespeople, corporate spies, trade shows, or Ethnographic discovery methods (searching for user patterns and habits) may also be used to get an insight into new product lines or product features.
   - Idea Generation or Brainstorming of new product, service, or store concepts - idea generation techniques can begin when you have done your

OPPORTUNITY ANALYSIS to support your ideas in the **Idea Screening Phase** (shown in the next development step).

2. **Idea Screening**

   The object is to eliminate unsound concepts prior to devoting resources to them.
   The screeners must ask at least three questions:
   Will the customer in the target market benefit from the product?
   What is the size and growth forecasts of the market segment/target market?
   What is the current or expected competitive pressure for the product idea?
   What are the industry sales and market trends the product idea is based on?
   Is it technically feasible to manufacture the product?
   Will the product be profitable when manufactured and delivered to the customer at the target price?

3. **Concept Development and Testing**

   Develop the marketing and engineering details
   Who is the target market and who is the decision maker in the purchasing process?
   What product features must the product incorporate?
   What benefits will the product provide?
   How will consumers react to the product?
   How will the product be produced most cost effectively?
   Prove feasibility through virtual computer aided rendering, and rapid prototyping
   What will it cost to produce it?
   Testing the Concept by asking a sample of prospective customers what they think of the idea.

4. **Business Analysis**

   Estimate likely selling price based upon competition and customer feedback
   Estimate sales volume based upon size of market.
   Estimate profitability and breakeven point

5. **Beta Testing and Market Testing**

   Produce a physical prototype or mock-up
   Test the product (and its packaging) in typical usage situations
   Conduct focus group customer interviews or introduce at trade show
   Make adjustments where necessary
   Produce an initial run of the product and sell it in a test market area to determine customer acceptance

6. **Technical Implementation**

   New program initiation
   Resource estimation
   Requirement publication
   Engineering operations planning
   Department scheduling
   Supplier collaboration

Logistics plan
Resource plan publication
Program review and monitoring
Contingencies - what-if planning

7. **Commercialization** (often considered post-NPD)
Launch the product
Produce and place advertisements and other promotions
Fill the distribution pipeline with product
Critical path analysis is most useful at this stage

These steps may be iterated as needed. Some steps may be eliminated. To reduce the time that the NPD process takes, many companies are completing several steps at the same time (referred to as concurrent engineering). Most industry leaders see new product development as a *proactive* process where resources are allocated to identify market changes and seize upon new product opportunities before they occur (in contrast to a *reactive strategy* in which nothing is done until problems occur or the competitor introduces an innovation). Many industry leaders see new product development as an ongoing process (referred to as continuous development) in which the entire organization is always looking for opportunities.

5.3 NPD Performance

Calantone et al., (1995) proposed new product development activities for enterprise performance and strategy. He utilized the ratio of investment, the investment growth rate, ratio of sales, sales growth rate, market share and growth rate as performance indexes. Table 6, Factors to consider for measures of innovation, lists a variety of measures that can guide thinking in the right direction and facilitate development of appropriate measures of innovation.

Table 6 Factors to consider for measures of innovation

Industry innovation indicators	**Business innovation index**	**Process innovation measures**
Innovation Funding, include R&D	Resources-Funding, Culture of Risk Taking, Rewards, Tools	Excellence in Research, Innovation Management, Time allocation (%)
New products, Services, or solution	Activities-Targets for innovation, Process of Innovation, Extent of Institutionalization, Idea Management, Internal and External Publications Knowledge Management, Internal and External Collaboration, Recognition	New Ideal Deployment, Extent of Improvement or Chang, Degree of Differentiation, Disruption or Innovativeness, Time to Innovate
Market Capitalization	Outputs-Patents, New Products, Services or Solutions, Sales Growth, Market Position or Ranking, Customer perceptions	Rate of Innovation, Savings, Opportunities

6 Combination of KM and NPD

Current, both KM and IM represent areas of management that seemed to reside in separate spheres of influence, with almost no impact on one another. Nevertheless, one major of management concern confronting organizations lies in market efficient use knowledge assets to create better, faster and more cost-effective innovations. A strategic management framework of new product development is proposed, as a concept model to help organizations understand how knowledge innovation can be managed in a more holistic, inclusive and coordinated manner. It provides a management tool for organizations to analyses whether their roles in strategic aspects of management, have been fulfilled. Figure 3 provides a pictorial for the potential integration of two disciplines, namely: innovation management and knowledge to introduce a strategic management method towards knowledge innovation as a source of new product development.

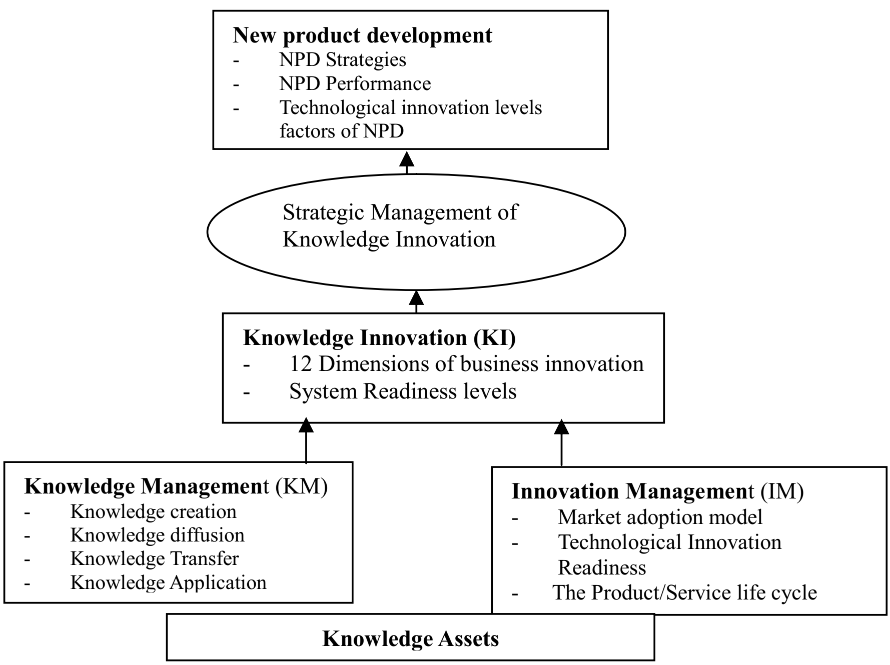


Fig. 3 A strategic management framework of product development

Cooper & Kleinschmidt (1998) suggest that the entire NPD process includes three stages: the plan stage, the development and test stage, the produce stage. Cooper (1994) divides the NPD process into five stages: Concept Generation, Product Planning,、Product Engineering, Process Engineering, Production , and

Process. There is a Gate between two stages used to examine whether the previous stage' work has accomplished and decide whether it can start the next stage's work. In this paper, we divide the NPD process into five stages: Idea Generation / Idea Screening (IG), Concept development and testing (CD), Business analysis (BA), Beta testing and Market testing (BT), and Technical Implementation and Commercialization (TI).

There are lots of views about the KM process as the NPD process. But as to NPD, there is a knowledge chain in the NPD process, so this paper considers the life cycles of the knowledge and divides the knowledge chain into six stages: Knowledge Identification, Knowledge Capture, Knowledge Storage, Knowledge Sharing, Knowledge Innovation, and Knowledge Application (Nonaka and Takeuchi, 1995).

In this paper, we divide the KM process into five stages: Knowledge creation, Knowledge Diffusion, Knowledge Transfer, Knowledge Applying, and Knowledge Innovation. . We combine the process of KM and the process of NPD in a model (Figure 4).

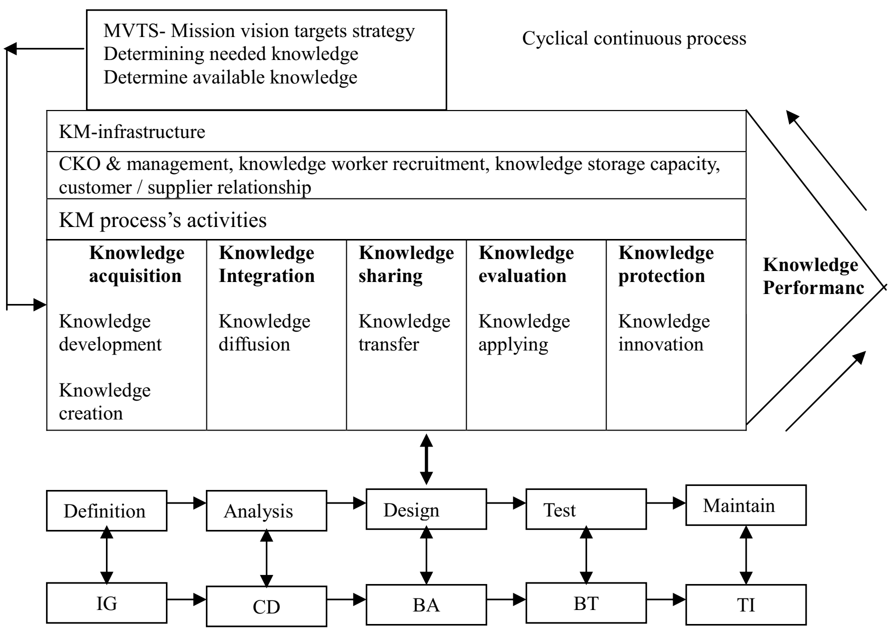


Fig. 4 The NPD process derived by KM System and the NPD's model

7 Case Study

LG Electronics Inc. (LGE) has mapped out a clear plan for reaching its goal of "Global Top 3 by 2010." The company's strategy for gaining market share is two-fold: fast innovation and fast growth. This is supported by its core competencies of product leadership, market leadership and people leadership. To align with LGE's corporate growth initiatives, the Telecommunication & Handset Company has been revising its product development process to drive innovation and growth. One effort for boosting innovation has been to increase research activities outside of Korea. To support growth, the company has been looking for ways to accelerate the development of new products. To achieve LGE's goals, management wanted to create a secure information infrastructure that would take advantage of the Web while providing immediate access to product information throughout the company, including overseas branches. A Product Lifecycle Management (PLM) system would provide the essential infrastructure LGE needed.

In addition to allowing people to work more efficiently, this type of infrastructure would:

(1) Permit the sharing of best practices and failure cases throughout the development team;
(2) Increase the re-usability of knowledge; and
(3) Permit real-time acquisition and analysis of test data.

The new PLM system also had to leverage the information in the existing product data management (PDM) system. With PLM facilitating the engineering change order (ECO) process, the automatic notification and delivery of documents has reduced lead time from 1.6 days to one-half day, a 68 percent improvement. A recent study by IDC shows that LGE mobile phones captured the largest share of the U.S. Code Division Multiple Access (CDMA) handset market in the first quarter of 2004, selling more than three million units to corner 26.8 percent of the market. In addition the company joined the list of the top six GSM manufacturers in the U.S.

8 Conclusion

This paper is based on knowledge management (creation, diffusion, transfer, application) and Innovation management (Technological Innovation Readiness, Market adoption model, The Product/Service life cycle) to explore how to lead the knowledge management into the new product invention's activities which utilize in knowledge innovation. Overall, from the result of this paper we could apply the knowledge innovation as a tool to integrate the NPD strategy and NPD performance. We believe this model may help company develop the successful new products and become a winner in this competitive world.

References

1. Amidon, D.M.: Innovation strategy for the knowledge economy: the Ken Awakening. Butterworth-Heinemann, Boston (1997)
2. Aoshima, Y.: Transfer of system knowledge across generations in new product development: empirical observations from Japanese automobile development. Industrial Relations 41(4), 605–628 (2002)
3. Beacham, J.: Succeeding through innovation: 60 minute guide to innovation, turning ideas into Profit (2006), `http://www.berr.gov.uk/files/file34902.pdf`
4. Calantone, R., Vickery, S., Deoge, C.: Business performance and strategic new product development activities: An empirical investigation. Journal of Product Innovation Management 12(3), 214–223 (1995)
5. Clark, C., Chew, W.B., Fujimoto, T.: Product development in the world auto industry. Brookings papers on Economic Activities, pp. 729-771 (1987)
6. Cooper, R.G.: Third-generation Product Innovation Management. New Product Process Journal 11, 3–14 (1994)
7. Cooper, R.G., Kleinschmidt, E.J.: Resource Allocation in the New Product process. Industrial Marketing Management 17(3), 249–262 (1998)
8. Cooper, R.G.: New product strategies: What distinguishes the top performance? Journal of Product Innovation Management 2(1), 151–164 (1984a)
9. Cooper, R.G.: The strategy-performance link in product innovation. R&D Management 14(4), 247–259 (1984b)
10. DeLong, D.W., Fahey, L.: Diagnosing cultural barriers to knowledge management. Academy of Management Executive 14(4), 113–128 (2000)
11. DoD, Defense Acquisition Guidebook (2006)
12. DoD, Technology Readiness Assessment (TRA) desk book, DUSD(S&T), Editor, Department of Defense (2005)
13. Ferry, J.: Flextronics, Staying Real in a Virtual World. Strategy + business Magazine, Booz Allen Hamilton (37), 9 (Winter 2004)
14. Goh, A.: Enhancing competitiveness through innovation: Issues and implications for Industrial Policy-Making. Journal of Applied Management and Technology 2(2), 1–23 (2004)
15. Hansen, M., Nohria, N., Tierney, T.: What's your strategy for managing knowledge? Harvard Business Review 77(2), 106–116 (1999)
16. Harkema, S.J., Browrys, M.J.: Managing Innovation Successfully: A Complex Process. In: European Academy of Management Annual Conference Proceedings, EURAM (2002)
17. Lee, H., Choi, B.: Knowledge management enablers, Processes, and organizational performance: An integrative view and empirical examination. Journal of Management Information System Systems 20(1), 179–228 (2003)
18. Mild, A., Taudes, A.: An agent-based investigation into the new product development capability. Computational and Mathematical Organization Theory 13(3), 315–331 (2007)
19. Sawhney, M., Wolcott, R.C., Arroniz, I.: The 12 different ways for companies to innovate. MIT Sloan Management Review 47(3), 75–81 (2006)
20. NASA, Mars Climate Orbiter, Mishap Investigation Board: Phase1 Report (1999)

21. Nonaka, I., Takeuchi, H.: The Knowledge Creating Company: How Japanese companies create the dynamics of innovation. Oxford University Press, New York (1995)
22. Nonaka, I., Takeuchi, H.: The knowledge-creation Company. Oxford University Publications, New York (1995)
23. Rogers, E.: New Product Adoption and Diffusion. Journal of Consumer Research 2, 290–301 (1976)
24. Rogers, E.: Diffusion of Innovations. The Free Press, New York (1995)
25. Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., Rebeck, K.: SMART vision: a knowledge management methodology. Journal of Knowledge Management 5(4), 300–310 (2001)
26. Sawhney, M., Wolcoff, R.C., Arroniz, I.: The 12 Different Ways for Companies to Innovate. Management of Technology and Innovation 47(3), 75–81 (Spring 2006)
27. Sharkie, R.: Knowledge creation and its place in the development of sustainable competitive advantage. Journal of Knowledge Management 7(1), 20–31 (2003)
28. Shin, M., Holden, T., Schmidt, R.: From knowledge theory to management practice: Towards an integrated approach. Journal of Information Processing and Management 37, 335–355 (2001)
29. Tsoukas, H.: The firm as a distributed knowledge system: A constructionist approach. Strategic Management Journal 17, 11–25 (1996)
30. Veryzer, R.W.: Discontinuous innovation and new product development process. Journal of Product Innovation Management 15(4), 304–321 (1998)
31. Von Krogh, G., Ichijo, K., Nonaka, I.: Enabling knowledge Creation. Oxford University Publications, New York (2000)

Cross-Functional Collaboration, Knowledge Transfer and Product Innovativeness: Contingency Effects of Social Context

Dirk De Clercq[1], Narongsak (Tek) Thongpapanl[2], and Dimo Dimov[3]

[1] Brock University, Canada
[2] Brock University, Canada
[3] Newcastle University

Abstract. A contingency perspective is used to examine how social capital influences the relationship between cross-functional collaboration and product innovativeness. Three dimensions of organizations' internal social context (social interaction, trust, and goal congruence) conducive to high-quality knowledge transfer are argued to increase firms' ability to convert cross-functional collaboration into product innovativeness. Several research hypotheses are tested based on a sample of 232 firms. It is found that the relationship between cross-functional collaboration and product innovativeness is amplified at higher levels of the three social capital dimensions. The study's implications for the role of knowledge transfer and social capital in exchange relationships are discussed.

1 Introduction

A firm's ability to develop new products and services depends not only on managing the external relationships it can use to be vigilant of ever-changing market conditions (Payne and Frow 2005) but also on ensuring buy-in from its different functional areas (Srivastava et al. 1998). The latter requires collaboration across different functions, such as R&D and marketing (De Luca and Atuahene-Gima 2007). But such cross-functional collaboration is fraught with challenges, as the interaction between people from different functional areas brings together varied "thoughtworlds" (Griffin and Hauser 1996), cultures, and attitudes (Gupta et al. 1986), which makes combining their knowledge to create new products difficult (De Luca and Atuahene-Gima 2007). As a relational component of cross-functional integration (Kahn 1996), cross-functional collaboration reflects the harmony of interdepartmental relationships (Xie et al. 2003). Thus, it taps into the unstructured, affective nature of interdepartmental exchanges rather than their structural components (Song et al. 2000). Significantly, the translation of cross-functional collaboration into product innovativeness thus is not automatic, because such collaboration cannot be easily regulated and often is intangible in nature (Appley and Winder 1977).

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 321–331.
springerlink.com

Because intrafirm knowledge transfers do not occur in isolation but rather are embedded in a social context, the nature of such context can play a prominent role in whether function-specific knowledge gets unlocked and combined to benefit the whole organization through the development of new products (Nahapiet and Ghoshal 1998). Concerns about resource allocations (Luo et al. 2006), political battles, and goal conflicts among functions (Ancona and Caldwell 1992), can easily undermine the effectiveness of collaborative efforts among departments. Yet despite prior research that examines the contingent nature of firms' ability to develop new products and services (e.g., Citrin et al. 2007; Montoya et al. 2009), we lack a clear understanding of how firms' product innovativeness might be driven by the interplay between cross-functional collaboration and the social context in which such collaboration takes place, particularly in view of promoting cross-functional knowledge transfer. Therefore, the key question driving this paper asks: How might the relationship between cross-functional collaboration and product innovativeness vary across different social contexts?

We address this question by considering the nature and role of social capital among functional departments. Social capital has emerged in management and organization research as a key aspect of organizations' social context, in that it promotes internal knowledge transfer and the creation of new knowledge and intellectual capital (Nahapiet and Ghoshal 1998). As such, a firm's internal social capital can be instrumental for leveraging internal relationships toward product innovativeness (Tsai and Ghoshal 1998). Innovation and new product development depend on various relational processes, such as internal social events (Lawson et al. 2009), trust development (Bosch-Sijtsema and Postman 2009), and shared values and understandings (Dougherty and Heller 1994).

We focus on three dimensions of firms' internal social capital (i.e., social interaction, trust, and goal congruence) and examine how they affect the relationship between cross-functional collaboration and product innovativeness, both individually and collectively. We argue that social interaction, trust, and goal congruence can each enhance the quality of knowledge transfer across functional departments (Bosch-Sijtsema and Postman 2009) and thus make cross-functional collaboration more beneficial for product innovativeness. Thus, our focus on intra-organizational social capital provides a further understanding of the merits of cross-functional collaboration for promoting innovation in different organizational contexts. We argue that the knowledge transfer required to translate collaborative efforts into product innovativeness can occur only when the organization's relational structure breeds openness and benevolence.

2 Theory and Hypotheses

2.1 Cross-Functional Collaboration and Product Innovativeness

We seek to understand the relational contingencies underlying the link between cross-functional collaboration and product innovativeness in the context of collaboration among midlevel managers responsible for different functions such as

R&D or marketing (Floyd and Wooldridge 1997). Such managers oversee the subprocesses involved in implementing an organization's higher-level, strategic decisions and epitomize the enactment of a firm's innovative pursuits. In their unique positions, from which they can evaluate and combine knowledge flows, these midlevel managers help leverage internal relationships to encourage product innovativeness (Floyd and Lane 2000).

Ideally, a firm should encourage close collaborative relationships between functional managers to develop new products and services (Lovelace et al. 2001). Although cross-functional collaborative relationships can be beneficial for product innovativeness (Sethi et al. 2001), such benefits do not come about automatically. For instance, managers may experience ambiguity in their collaboration with peers in other departments, given the unstructured nature of such collaboration, which can lead to frustration and anxiety (Song et al. 2000). Further, the conversion of collaborative relationships, even if marked by harmony, into product innovativeness can be hampered by uncertainty about how different departments will contribute to the generation of specific deliverables, such as the provision of timely and high-quality knowledge (Adams et al. 1998). Strong collaborative relationships, though necessary for product innovativeness, also may create a sense of relinquished power that can function as a disincentive to disclose function-specific knowledge (Kim and Mauborgne 1998).

2.2 Social Capital and Knowledge Transfer

The extent to which cross-functional collaboration can enhance the emergence of innovative solutions within the organization comes from the very ability to assemble and combine dispersed knowledge across functional boundaries (Floyd and Lane 2000). Leveraging knowledge to exploit collaborative relationships requires organizational mechanisms that unlock knowledge from its holders (Nahapiet and Ghoshal 1998). We argue that firms' ability to accomplish such "unlocking" is strengthened by the level of social capital embedded in their interfunctional interactions. Social capital represents an organizational characteristic that reflects "the sum of the actual and potential resources embedded within, available though, and derived from the network of relationships possessed by an individual or social units" (Nahapiet and Ghoshal 1998, p. 243). It is instrumental for firms' ability to create new knowledge and intellectual capital (Nahapiet and Ghoshal 1998) and has been shown to increase firms' level of innovation (Tsai and Ghoshal 1998).

But how can social capital unlock the benefits of cross-functional collaboration? Nahapiet and Ghoshal (1998) identify three key dimensions of social capital: structural, relational, and cognitive. The structural dimension captures the social ties between organizational members and internal network configurations. The relational dimension captures personal relationships developed among exchange partners through a history of interactions, including trust, norm obligations, and identification. The cognitive dimension captures shared representations and interpretations, such as shared goals, language, and meanings (Nahapiet and Ghoshal 1998). Similarly, and drawing from prior conceptualizations of social capital (De Clercq and Sapienza 2006), we deem three components of cross-functional social capital instrumental for unlocking function-specific knowledge: social interaction, trust, and goal congruence.

First, social interaction captures the strength of the social relationships between functional managers and the informal nature of these relationships (Yli-Renko et al. 2001). The exchanges between functional departments differ with respect to the presence of close personal relationships between functional managers in their day-to-day activities, as well as the extent to which these managers spend significant time together in social situations outside work (Tsai and Ghoshal 1998). Second, trust refers to functional managers' positive expectations about others' motives in situations entailing risk and vulnerability (Boon and Holmes 1991). In other words, trust instills a willingness to leave oneself vulnerable to the actions of others and is particularly relevant in uncertain and risky situations (Dayan et al. 2009). Third, goal congruence refers to the extent to which functional managers across different departments share the same goals (Xie et al. 2003). This dimension reflects the presence of a shared paradigm that facilitates how individual departmental interests can fit into the firm's overall strategy and goals (Pinto et al. 1993). Thus, goal congruence can help coordinate the activities of individual departments toward the accomplishment of the common good for the whole organization (McDonough 2000).

We start with the intuitive premise that cross-functional collaboration enhances product innovativeness and focus on the internal contingencies that may amplify this relationship. Our conceptual model appears in Figure 1.

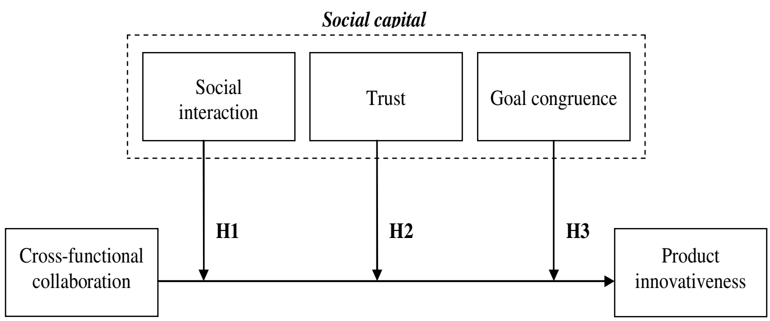


Fig. 1 Conceptual Model

2.3 Moderating Effect of Social Interaction

Social interaction captures the presence of social contacts and personal relationships between functional departments. Tsai and Ghoshal (1998) find that social interaction enhances high-quality knowledge transfer by stimulating close cooperation among organizational actors in their efforts to achieve the firm's goals. In turn, we hypothesize that the positive relationship between cross-functional collaboration and product innovativeness should be stronger when strong social ties exist between functional departments. Strong ties facilitate the ability to *learn* from collaborative exchanges between partners (Uzzi 1997). Uzzi (1997) finds that a critical aspect of socially "embedded" ties is an improved ability to solve problems jointly, which enables decision makers to get direct feedback from one another, search deeply for solutions, and integrate these solutions into day-to-day practices. Similarly, Heide and Miner (1992) indicate that when collaborative partners confront different opinions, close social interactions enhance their mutual adjustment and efforts to engage in shared problem solving.

H_1: The positive relationship between cross-functional collaboration and product innovativeness is moderated by the level of social interaction, such that this relationship is stronger for higher levels of social interaction.

2.4 Moderating Effect of Trust

We also consider the role of the goodwill aspect of trust or the willingness of functional managers to leave themselves vulnerable to the actions of colleagues in other departments (Dayan et al. 2009). The beneficial effect of cross-functional collaboration on product innovativeness should be greater when higher levels of such trust exists between the different functions. Trust reduces the time and money consumed in monitoring the behavior of functional peers (Zaheer et al. 1998) and therefore enables managers to devote more time to productive activities, such as figuring out how their own knowledge can be effectively combined with that of others during the development of new products or services (Jassawalla and Sashittal 1998). Further, when functional managers are confident that their colleagues will *not* take advantage of them—for instance, by demanding excess resources irrespective of other departments' needs—even if the opportunity arises, their collaborative efforts should be more effective, given their greater willingness to transfer privileged and confidential knowledge (Yli-Renko et al. 2001) or even transfer insights derived from prior failures (De Luca and Atuahene-Gima 2007).

H_2: The positive relationship between cross-functional collaboration and product innovativeness is moderated by the level of trust, such that this relationship is stronger for higher levels of trust.

2.5 Moderating Effect of Goal Congruence

Goal congruence represents the cognitive dimension of social capital and refers to the degree to which functional managers' goals and values converge (Nahapiet and Ghoshal 1998). For firms to develop new products or services, their managers need to understand the "ways that things are done" in other departments, so that their own and other's knowledge bases can be effectively integrated (Szulanski 1996; Tsai and Ghoshal 1998). In turn, we argue that the positive impact of cross-functional collaboration on product innovativeness will be enhanced at higher levels of goal congruence. Goal congruence should increase the extent to which cross-functional collaboration can be leveraged toward product innovativeness, in that common goals induce a common "dominant logic," that is, a preference for how to process knowledge and how to solve problems (Lane and Lubatkin 1998). Such logic creates a deeper understanding of which knowledge is most important to solve a particular problem and how to combine disparate pieces of knowledge in a creative manner (Lane and Lubatkin 1998). Thus, when different departments share the same goals and expectations, they can achieve improved insights into the acquisition and delivery of function-specific knowledge necessary for the development of new products (Xie et al. 2003).

H_3: The positive relationship between cross-functional collaboration and product innovativeness is moderated by the level of goal congruence, such that this relationship is stronger for higher levels of goal congruence.

3 Research Methods

3.1 Sample and Data Collection

To ensure the wide applicability of our findings, we test our hypotheses with a sample of firms active in a variety of industrial sectors. We obtained, from a private market research company, a list of 1,500 randomly selected Canadian firms, representative of the country's provinces and industrial sectors. Similar to approaches used in prior research (e.g., Song et al. 2006), we used a single-respondent design and obtained contact information about managers active in either an R&D- or marketing-related function. We then sent a survey instrument to one randomly selected functional manager per firm. To pretest the survey and ensure that our questions were clear and understandable, we undertook informal interviews with six randomly chosen functional managers (three R&D, three marketing) who were not included in the initial sample and with whom we discussed the survey instrument, as well as the challenges associated with cross-functional cooperation in their firms. Their input helped us improve the readability and relevance of our survey instrument.

3.2 Measures of Constructs

In line with our research focus, our measures assess respondents' perceptions about the relationship between the marketing- and R&D-related functions in their organizations, and the questions in the survey were worded to capture phenomena that take place at the firm level rather than functional manager level.

4 Analysis and Results

In Table 1, we provide the regression results for several models. Model 1 contains specific control variables, Model 2 adds the effect of cross-functional collaboration, and Model 3 adds the direct effects of social interaction, trust, and goal congruence. In Model 2, consistent with the starting point of our theoretical exposition, we find a positive effect of cross-functional collaboration on product innovativeness ($\beta = .227$, $p < .05$), and this collaboration variable explains additional variance ($\Delta R^2 = .024$, $p < .01$). In Model 3, among the social capital components, only social interaction has a significant, direct effect on product innovativeness ($p < .05$). Model 4 reveals a positive and significant interaction effect between cross-functional collaboration and social interaction on product innovativeness ($\beta = .249$, $p < .01$), which provides

Table 1 Regression Results (Dependent Variable: Product Innovativeness) (N = 232)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Decision autonomy	.174**	.133*	.156*	.134*	.166**	.159*
Shared responsibility	.172**	.071	.072	.079	.081	.077
Company size (log employed)	.034	.032	.038	.044	.046	.043
Company age (years)	-.006***	-.007***	-.006***	-.006***	-.006***	-.006***
Industry: manufacturing[a]	.566	.504	.550	.578	.591	.590
Industry: services	.456	.428	.442	.488	.479	.495
Industry: mining	.149	.194	.186	.239	.282	.274
Industry: construction	1.093*	1.053^{+}	1.115*	1.127*	1.153*	1.147*
Industry: transportation	.091	.130	.162	.077	.192	.129
Industry: wholesale	.546	.618	.633	.696	.696	.695
Industry: retail	1.189*	1.232*	1.254*	1.122*	1.091*	1.218*
Marketing-related function[b]	-.032	-.038	-.039	-.044	-.038	-.033
Cross-functional collaboration		.227*	.214*	.255*	.257*	.240*
Social Interaction			.188*	$.136^{+}$	.212**	.199*
Trust			-.059	-.030	-.047	-.048
Goal congruence			-.060	-.057	-.093	-.084
H_1: Cross-functional collaboration × Social interaction				.249**		
H_2: Cross-functional collaboration × Trust					.215**	
H_3: Cross-functional collaboration × Goal congruence						.133*
R^2	.184***	.208	.230	.263	.261	.242
•R-square		.024**	.022	.033**	.031**	$.012^{*}$

Notes: Unstandardized coefficients (two-tailed *p*-values). ***$p < .001$; **$p < .01$; *$p < .05$; $^{+}p < .10$.
[a] Base case = Finance industry; [b] Base case = R&D-related function.

support for Hypothesis 1. In Model 5, the interaction effect between cross-functional collaboration and trust on product innovativeness is positive and significant (β = .215, $p < .01$), which supports Hypothesis 2. Model 6 shows support for Hypothesis 3; the interaction effect between cross-functional collaboration and goal congruence on product innovativeness is positive and significant (β = .133, $p < .05$).

5 Discussion

5.1 Contributions to Research

We test the argument that a firm's ability to leverage cross-functional collaboration into product innovativeness depends on the extent to which its internal social context facilitates knowledge flows across functional departments (De Luca and Atuahene-Gima 2007). To this end, we use the concept of social capital, borrowed from management literature (e.g., Nahapiet and Ghoshal 1998; Tsai and Ghoshal 1998; Yli-Renko et al. 2001), to argue that firms' ability to convert intra-organizational collaboration into product innovativeness—and the associated need to exhibit high-quality knowledge transfer—depends on the presence of social interaction, trust, and goal congruence across functional departments. Our approach thus contributes to the scholarly conversation about the internal conduits for product innovativeness (De Luca and Atuahene-Gima 2007; Lovelace et al. 2001) and explicates how a firm can optimize its internal social context to exploit its integrative efforts across functional departments.

Our three hypotheses are supported. First, the beneficial aspects of cross-functional collaboration for product innovativeness become more pronounced when stronger social ties connect functional departments. When cross-functional interactions are informal, functional departments such as R&D and marketing might be more open and forthcoming in response to disagreements about how to implement innovation-related decisions (De Dreu et al. 2000). Second, when functional managers have confidence in one another's honesty and truthfulness, they can invest more in productive exchanges that unlock function-specific knowledge rather than in activities aimed at monitoring and checking whether other departments will take advantage of them and their own interests (Jassawalla and Sashittal 1998). Third, goal congruence amplifies the benefits of cross-functional collaboration: The presence of shared goals increases the openness of different functions about one another's viewpoints and, in doing so, favors the development of new, innovative initiatives when they emerge from cross-functional interactions (Xie et al. 2003).

5.2 Contributions to Practice

From a practice perspective, the study's results do not only have implications for the intra-firm context but also for the conversion of *inter*-firm collaboration into innovative outcomes. When firms co-develop new products or enter new markets, their top management needs to consider the social context in which managers in "boundary spanning" roles operate, and encourage these managers to combine and integrate their unique skills and knowledge openly with one another. In particular, as much as they can, top management should encourage informal interactions across firms, breed trust among boundary spanners, and stimulate firms' adherence to the common goals of the inter-firm partnership. In turn, individual managers should move away from their identities associated with their particular organization and instead imagine themselves and the representatives of other firms as "partners" who share a set of common interests: to combine their knowledge and thereby realize the partnership's innovative goals through collaborative efforts. Put differently, in the context of inter-firm collaboration, the relational boundary conditions studied herein—social interaction, trust, and goal congruence—encourage boundary spanners to focus on "pie-expanding" efforts that benefit both firms, rather than the fight for resources. Overall, these findings also provide insight into the selection criteria that firms with innovative aspirations should maintain when appointing managers responsible for the interactions with other firms. Not only should these managers be proficient in their respective domains of expertise, they also should be effective team players, willing to go out of their way to build and cultivate a "social community" across their organization's borders (Tsai 2000).

References

Ancona, D., Caldwell, D.: Demography and design: predictors of new product team performance. Organization Science 3(3), 321–341 (1992)

Appley, D.G., Winder, A.E.: An evolving definition of collaboration and some implications for the world of work. Journal of Applied Behavioral Science 13(3), 279–291 (1977)

Atuahene-Gima, K., Murray, J.Y.: Exploratory and exploitative learning in new product development: a social capital perspective on new technology ventures in China. Journal of International Marketing 15(2), 1–29 (2007)

Bosch-Sijtsema, P.M., Postman, T.J.B.M.: Cooperative projects: capabilities and governance mechanisms. Journal of Product Innovation Management 26(1), 58–70 (2009)

Citrin, A.V., Lee, R.P., McCullough, J.: Information use and new product outcomes: the contingent role of strategy type. Journal of Product Innovation Management 24(3), 259–273 (2007)

Dayan, M., Di Benedetto, C.A., Colak, M.: Managerial trust in new product development projects: its antecedents and consequences. R&D Management 39(1), 21–37 (2009)

De Clercq, D., Sapienza, H.J.: Effects of relational capital and commitment on venture capitalists' perception of portfolio company performance. Journal of Business Venturing 21(3), 326–347 (2006)

De Dreu, C.K.W., Weingart, L.R., Kwon, S.: Influence of social motives in integrative negotiation: a meta-analytic review and test of two theories. Journal of Personality and Social Psychology 78, 889–905 (2000)

De Luca, L.M., Atuahene-Gima, K.: Market knowledge dimensions and cross-functional collaboration: examining the different routes to product innovation performance. Journal of Marketing 71, 95–112 (2007)

Dougherty, D., Heller, T.: The illegitimacy of successful product innovation in established firms. Organization Science 5(2), 200–218 (1994)

Floyd, S.W., Lane, P.J.: Strategizing throughout the organization: managing role conflict in strategic renewal. Academy of Management Review 25(1), 154–177 (2000)
Gupta, A.K., Raj, S.P., Wilemon, D.L.: A model for studying R&D-marketing interface in the product innovation process. Journal of Marketing 50, 7–17 (1986)
Heide, J.B., Miner, A.S.: The shadow of the future: effects of anticipated interaction and frequency of contact on buyer-seller cooperation. Academy of Management Journal 35, 265–291 (1992)
Jassawalla, A.R., Sashittal, H.C.: An examination of collaboration in high-technology new product development processes. Journal of Production Innovation Management 15(5), 237–254 (1998)
Kahn, K.B.: Interdepartmental integration. a definition with implications for product development performance. Journal of Product Innovation Management 13(2), 137–151 (1996)
Kim, W.C., Mauborgne, R.: Procedural justice, strategic decision making, and the knowledge economy. Strategic Management Journal 19, 323–338 (1998)
Lane, P.J., Lubaktin, M.: Relative absorptive capacity and interorganizational learning. Strategic Management Journal 19, 461–477 (1998)
Larson, A.: Network dyads in entrepreneurial settings: a study of the governance of exchange relationships. Administrative Science Quarterly 37, 76–104 (1992)
Lovelace, K., Shapiro, D.L., Weingart, L.R.: Maximizing cross-functional new product teams' innovativeness and constraints adherence: a conflict communications perspective. Academy of Management Journal 44, 779–794 (2001)
Luo, X., Slotegraaf, R.J., Pan, X.: Cross-functional coopetition: the simultaneous role of cooperation and competition within firms. Journal of Marketing 70(2), 67–80 (2006)
McDonough III, E.F.: Investigation of factors contributing to the success of cross-functional teams. Journal of Product Innovation Management 17(3), 221–235 (2000)
Montoya, M.M., Massey, A.P., Hung, Y.-T.C., Crisp, C.B.: Can you hear me now? Communication in virtual product development teams. Journal of Product Innovation Management 26(2), 139–155 (2009)
Nahapiet, J., Ghoshal, S.: Social capital, intellectual capital, and the organizational advantage. Academy of Management Review 23, 242–268 (1998)
Payne, A., Frow, P.: A strategic framework for customer relationship management. Journal of Marketing 69, 167–176 (2005)
Sethi, R., Smith, D.C., Park, C.W.: Cross-functional product development teams, creativity, and the innovativeness of new consumer products. Journal of Marketing Research 38(1), 73–85 (2001)
Song, X.M., Dyer, B., Thieme, R.J.: Conflict management and innovation performance: an integrated contingency perspective. Journal of the Academy of Marketing Science 34, 341–356 (2006)
Song, X.M., Xie, J., Dyer, B.: Antecedents and consequences of marketing managers' conflict handling behaviors. Journal of Marketing 64(1), 50–66 (2000)
Srivastava, R.K., Shervani, T.A., Fahey, L.: Market-based assets and shareholder value: a framework for analysis. Journal of Marketing 62, 2–18 (1998)
Tsai, W.: Social capital, strategic relatedness and the formation of intraorganizational linkages. Strategic Management Journal 21, 925–939 (2000)
Tsai, W., Ghoshal, S.: Social capital and value creation: the role of intrafirm networks. Academy of Management Journal 41, 464–476 (1998)
Uzzi, B.: Social structure and competition in interfirm networks: the paradox of embeddedness. Administrative Science Quarterly 42, 35–67 (1997)

Xie, J., Song, X.M., Stringfellow, A.: Antecedents and consequences of goal incongruity on new product development in five countries: a marketing view. Journal of Product Innovation Management 20(3), 233–251 (2003)

Yli-Renko, H., Autio, E., Sapienza, H.J.: Social capital, knowledge acquisition and knowledge exploitation in young technology-based firms. Strategic Management Journal 22, 587–614 (2001)

Zaheer, A., McEvily, B., Perrone, V.: Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. Organization Science 9(2), 141–159 (1998)

Integral Conceptual Design Workshop: Innovation by Knowledge Transfer and Knowledge Creation

Wim Zeiler and Perica Savanovic

Technische Universiteit Eindhoven, Netherlands
e-mail: w.zeiler@bwk.tue.nl

Abstract. Innovation in the Building Industry is necessary to meet the new demands of society. In order to enhance team design in the most crucial phase for innovation, the conceptual design phase, a design method is proposed: Integral Design. This design method uses morphological charts which are transformed to a morphological overview as a framework for reflection on the design process itself by the design team and their stakeholders (project managers, clients). This design method supports creation of innovative building design concepts by design knowledge transfer and knowledge creation based on the 'concept space' and 'knowledge space' of the Concept-Knowledge (C-K) theory of Hatchuel and Weil. To reach for organizational/cultural innovation as well as product and process innovation, the design method was developed in cooperation with the Dutch Society of Architects, BNA, and the Dutch society of consulting engineers, ONRI. One of the main results achieved is the inclusion of the method in workshops for the Royal Institute of Dutch Architects' permanent professional development program. Already more than 200 professional participated in these workshops.

Keywords: Integral Design, C-K theory, knowledge transfer, knowledge creation.

1 Introduction

The design of buildings is complex and therefore the building industry is rather traditional in their approach to the design process and innovation is rare. As a result the built environment uses 40% of all our energy for conditioning the buildings. This results in a major contribution to the emissions that increase the effect of global warming. Building designs need to provide solutions for increasingly complex programs of requirements, especially related to sustainability issues ranging from flexible use to energy saving measures while maintaining and even increasing comfort level of the users. Therefore building design involves many experts from different disciplines. As complexity and scale of design processes of buildings increase, traditional approaches may no longer suffice (van Aken 2005). The present inadequate cooperation between different disciplines in the design

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 333–343.
springerlink.com

process is a main cause of the large failure costs in the building industry. The estimated productivity loss in the Dutch building practice is about 8–10% of the total construction costs (€ 80 billion) per year (USP Marketing Consultancy, 2008).

Synergy between the different disciplines involved in the design process is necessary to attain the best designs. It no longer suffices to just merely solve the problems which arise at the level of detailing on the borderlines of disciplines.

To improve this situation, changes on the three levels are required (Bax & Trum 2000, Friedl 2000):

1. Process level – to improve the design process for all involved design disciplines;
2. Product level – to improve the final product (building as a whole, as well as its parts);
3. Organization/Culture level – to bridge the gap between 'Design' and 'Engineering' worlds, in case of the building design specifically between architects and consulting engineers (structural, building physics and building services).

To reach for all three aims, an approach is needed which stimulates interaction between research, education and practice. By analyzing building design in a holistic way an approach was developed which incorporates the ongoing transformation towards an acquaintance society which causes structural changes in the learning and work demands of professionals (Nonaka and Takeuchi 1995). Knowledge is crucial for the success of problem solving and task performance (Buckingham Shum 1997) as well as the necessary skills to confidently and successfully handle new complex design tasks (Adems et al. 2003). New approaches are needed to bridge the gap between the worlds of theory and practice in building industry which look at designing as a process in which the concepts of function, behavior and shape of artifacts play a central role (Vermaas & Dorst 2007). Such integral design approach can eventually lead to an integral process, team and method – all the required conditions for innovation of the end product; the building (Seppänen et al 2007).

The main body of the paper starts (Section 2) with the development of the Integral Design (ID) method: a design method to support that the design process possesses everything essential and helps to merge the different perspective of all designers and engineers involved in the design process. The core of this method is the use of a process model to divide the design process in different phases and levels of abstraction. This makes it possible to focus on the different design phases and to develop specific tools to support the process within such a phase. The tool which we use for the conceptual design phase is coming from the mechanical engineering domain: morphological charts. By combining morphological charts of each individual building design discipline, a morphological overview is created. This morphological overview represents the interpretation of the design task and the design knowledge within the design team related to the design task. As such this leads to a representation of the problem and solution space. The main aim of the ID-method approach is to improve conceptual design (the process level) in order to increase the potential for creation of innovative integral design concepts (the product level). Positive results at these two levels eventually will trigger and support the much-needed culture change (Wichers Hoeth and Fleuren, 2001) in (Dutch) building design practice.

In section 3 the Concept-Knowledge (C-K) theory of Hatchuel and Weil is introduced to further enhance stimulation of innovative concepts. Further the relation between the morphological overviews and the C-K theory is explained to reach knowledge transfer and knowledge creation, both essential elements for innovation. To test the derived design method workshops for professionals, architects and engineers, in building design practice were held which are described in section 4. In section 5 the results are presented of the application of the ID-method within the workshops. Finally, the paper ends with a short discussion of the developed ID-method use to stimulate innovation in (building) industry compared to another method, the KCP workshops (section 6). Finally in section 7 some conclusions are given about the added value of the presented approach for innovation and knowledge transfer/creation in the Dutch building industry

2 Methodology: Integral Design Method

During the early 1970s a prescriptive design method was developed in the Netherlands to innovate and teach design (Pahl et al. 2006). It was based on the synergetic abstraction of the German and Anglo-Saxon design methods of that period. This design method was chosen for further development into an Integral Design (ID) method, because it is still one of the few models that explicitly distinguishes between stages and activities, and the only method that emphasises the recurrent execution of the process on every level of complexity (Blessing 1994). Distinctive feature of our ID method is the four-step pattern of activities which occurs at each level of abstraction within the design process with possible iteration loops, see Fig.1: interpretation (define/analyze), generating (generate/synthesize), selecting(evaluate/select) and shaping (implement/application)

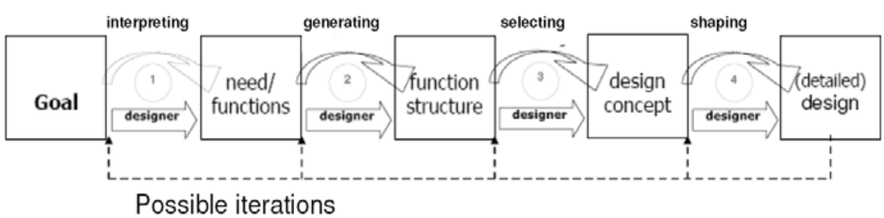


Fig. 1 The four-step pattern of Integral Design method with possible iteration loops

By introducing different levels of abstraction the Integral Design method allows the designer to limit the complex design question to smaller sub-questions. Abstraction to us is the selective examination of certain aspects of a problem and this helps the designer to decompose a complex design question into problems of manageable size. This simplification by abstraction leads to viewing designing as a process in which the concepts of function, behavior and structure of artifacts play a central role.

A distinguishing feature of Integral Design is the use of morphological charts for design activities in each phase of the design process. In these morphological charts functions and aspects to be fulfilled are vertically listed in a kind of matrix, and connected possible solutions to these functions and aspects are listed horizontal. By using morphological charts each design discipline can list, from their own perspective, the necessary functions and aspects decomposed from the program of demands and the related possible solution to them. Through this approach all the design team members have to come up with their interpretation and possible solutions to the design task. Now every designer sees the results of the different interpretations in the morphological chart and they can discuss aspects which are not clear to them. Immediately the reflection in action on the design process is initiated through this. The advantage of this approach is that the discussion comes after the preparation of the individual morphological charts. As each designer uses his own interpretation and representation, in relation with his specific discipline based knowledge and experience, this gives an overview of different discipline based interpretations of the design brief. This results in a combined interpretation of the design problem.

Using the morphological charts made by each individual designer, we can combine them to a morphological overview. This morphological overview is generated by combining the different morphological charts made by each discipline after discussion on and the selection of functions and aspects of importance for the specific design. The whole process is done in two steps: first the functions and aspects, then the possible related solutions, see Fig. 2.

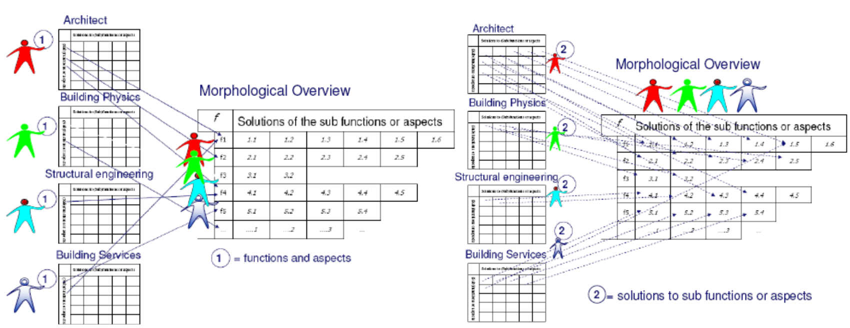


Fig. 2 Building the morphological overview; Step 1; The Morphological overviews show the agreed functions and aspects (1)of the different morphological charts. Step 2: The Morphological Overview with the agreed on sub solutions (2) from the separate morphological charts.

3 C-K Theory

Generally speaking, design thinking is a creative process based around the transformation of needs into solutions. In this process existing knowledge and information about the actual needs of the principle forms the basis to work from. If solutions based on existing knowledge are not adequate, this knowledge has to be transformed into new, unknown concepts. For innovation it is essential to stimulate these unknown concepts (Hatchuel and Weil 2007). Hatchuel and Weil make in their C-K(Concept-Knowledge) theory the distinction between two 'worlds': the world of knowledge and the world of concepts. Within the integral approach space K is defined by the initial design knowledge that participants bring into the design team. The transformations within and between the concept and knowledge spaces are accomplished by the application of four operators (Hatchuel and Weil, 2003): K-C, C-K, C-C and K-K. The last two operators are internal to the concept and knowledge spaces, and are not particularly relevant to the expansion of both solution spaces. The first two operators cross the Concept-Knowledge domain boundary, and are significant in the sense that they reflect a change in the logical status of the propositions under consideration by the designer (from no logical status to true or false, and vice versa).

The definition of design by C-K theory (Hatchuel and Weil, 2003) allowed us to approach design concepts as interpretation of knowledge transfer and knowledge creation. The C-K theory defines design as the interplay between two interdependent spaces having different structures and logics. This process generates co-expansion of two spaces, space of concepts C and space of knowledge K, see Fig. 3. As such the could be explained as the mechanism for knowledge transfer (K-K), and knowledge creation (C-K).

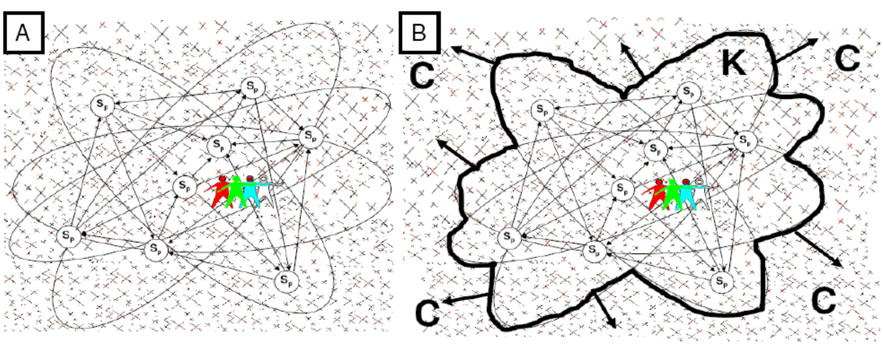


Fig. 3 Solution space new object design knowledge (nODK) and possible expansion of the solution space by Integral Design Concepts (IDC) as result of expansion from space K to space C

The transformation of individual morphological charts into one morphological overview aims at reaching consensus about the most important aspects and functions. Through this process individual interpretation, the reflection of each designer is now transferred into a group perspective. In the morphological overviews all interpreted functions (step 1, Fig. 4) and all generated (sub) solutions (step 2, Fig. 4) are presented by 'chunks' of object design knowledge, can be structured.

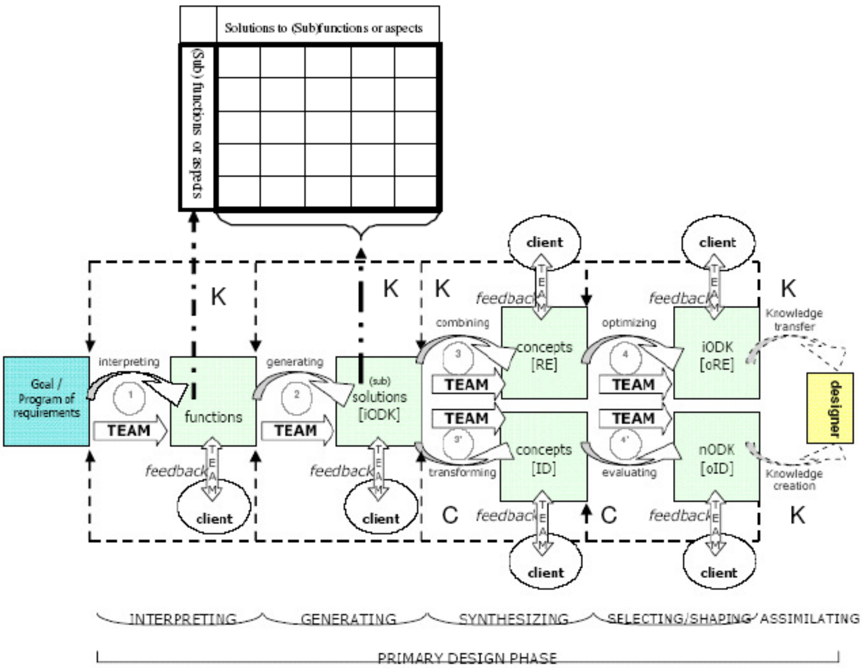


Fig. 4 ID-method and the relation with the morphological overview and C-K theory

Since the object of design is used as the reference, this knowledge is further specified as initial object design knowledge iODK (Fig. 4). Making object design knowledge explicit through the morphological overview enables designers to use it for the creation of design concepts by selecting combinations of sub-solutions from the morphological overview. These combinations are either integral design concepts (IDC) when new elements are introduced or just 'plain' combinations (RE).

Optimizing chosen redesigns will gradually lead to detailed solutions. These are optimized i'ODK, see step 4 in Fig.4. The focus is on the possibility of expanding the concept space with integral design concepts (step 3'- Fig. 4: ID), in order to create the potential for the creation of new object design knowledge (step 4'- Fig. 4, nODK). Concepts acquired through transformation of iODK into IDC, see step 3' in Fig.4, are regarded as integral concepts. This is a result of the so-called designer's 'creative leap', triggered by (aspects of) presented (sub) solutions and their possible connections. This can be supported with different creativity stimulating techniques, such as par example TRIZ, when ever necessary.

4 Experiments

Workshops settings are a suitable environment for the testing of design support tools for building design teams. Since 2005 we have organized 5 series of workshops for experienced architects and engineers. In the final workshop series the configuration (Fig. 5) changes stepwise from the traditional building design process type to the setting to stimulate innovation.

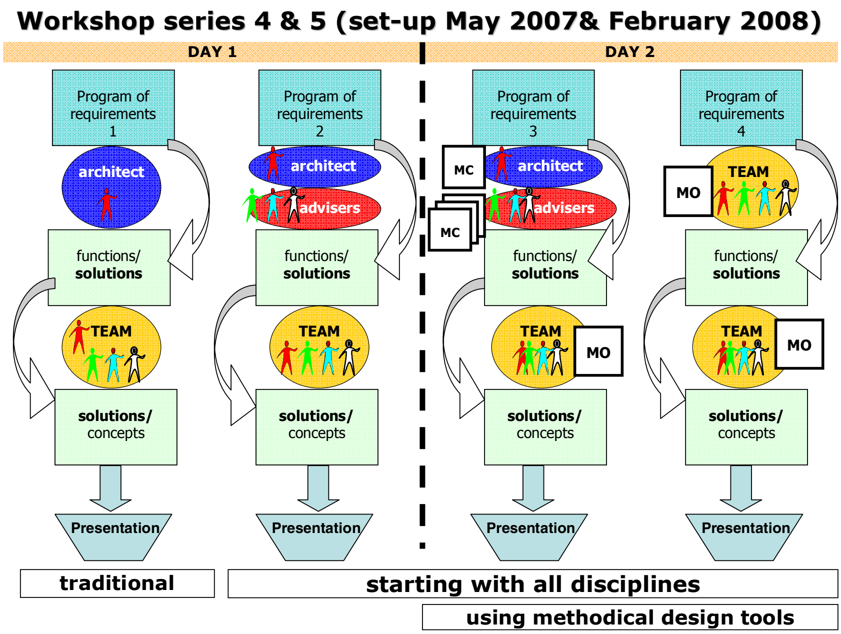


Fig. 5 Workshops series 4 & 5, four different design set ups of participants and use of Morphological Charts (MC) or Morphologic Overviews (MO) during the design sessions within two day

The workshops start with a lecture introducing Integral Design and are followed with other supportive/informative lectures about sustainable energy systems and the use of morphological overviews. The design tasks during the two days are on the same level of complexity and were used in all workshops. After each design session the participants present the results to each other and get feedback from the organizers. Starting with the traditional sequential approach during the first two design sessions on day 1, which provide reference values for comparing the effectiveness of the method, the perceived “integral approach” is reached through phased introduction of two major changes:

(1) all disciplines start working simultaneously within a design team setting from the very beginning of the conceptual design phase,
(2) morphological overviews of the integral design process model are applied.

The second set up of the design sessions allows simultaneous involvement of all design disciplines on a design task, aiming to influence the amount of considered design functions/aspects. Additional application of morphological overviews during the set up of the third design session demonstrates the effect of transparent structuring of design functions/aspects on the amount of generated (sub) solution proposals. Additionally, the third setting provides the possibility of one full learning cycle regarding the use of morphological overviews.

5 Results

Over the past four years the Integral Design approach has been tested in a series of 5 workshops, typically including around twenty participants and lasting for two or three days. A total of 124 designers participated in the workshop series, in which 74% of the designers were present during all of the days. Directly at the end of the workshop the participants were asked to fill in a questionnaire on the importance of the use of morphological overviews within the design process and on the concept of the workshops themselves. The participants had to rate the answers between 1 (very poor) to 10 (excellent). The average results were then determined; they varied between 7,5 to 8,1. So the experience by the professionals is positive, see Fig. 6.

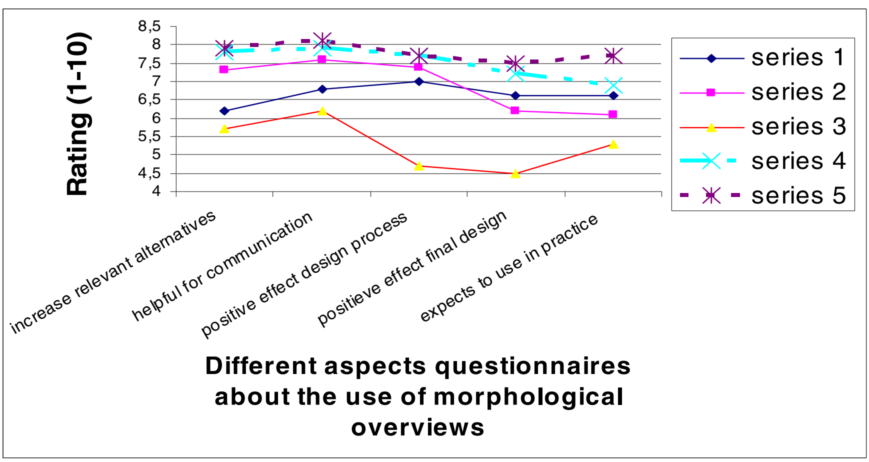
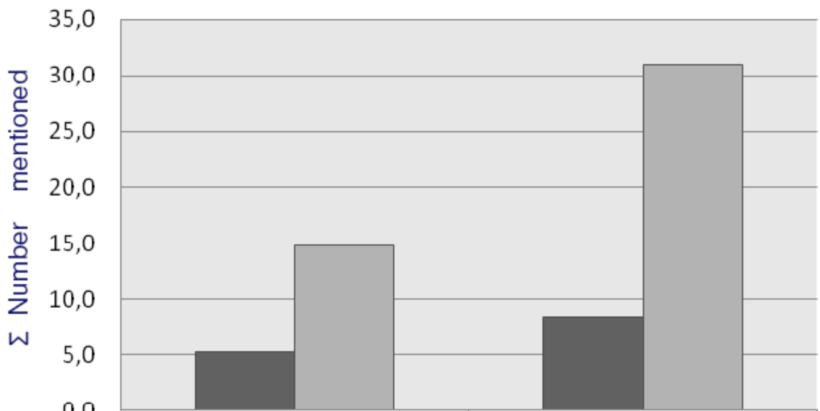


Fig. 6 Overview results questionnaires participants' professional workshops series 1- 5

Concerning the results of our approach we looked into the extension of the solution space and the analysis possibilities of the design process through morphological overviews. To conclude this section comparison is made between settings 1 and 4 of the final workshop 5. Fig. 7 shows the number of aspects and sub solutions generated by the teams in the two different settings 1 and 4, this clearly shows that, as expected, more aspects and sub solutions were generated in setting 4 compared to setting 1.



	setting 1	setting 4
aspects	5,2	8,4
sub solutions	14,8	31,0

Fig. 7 Averages of the amount of design aspects and sub solutions generated by design teams during design settings 1 and 4

6 Discussion

Although morphological charts are used in mechanical engineering design domain, they are rarely used in a multi-disciplinary context. The combining of the mono-disciplinary morphological charts into a morphological overview leads to a new approach for the support of knowledge transfer and knowledge creation. This is similar to the developed KCP (Knowledge Concepts Proposal)-workshops, derived from the C-K (Concept-Knowledge) theoretical framework in collaborative exploration in France at Ecole des Mines de Paris by Hatchuel and Weil (Elmquist and Segreslin 2009). These KCP-workshops aim at structuring collaborative exploration of an innovation field. The results are a structured set of innovative concepts for further development (Hatchuel 2009). The KCP-workshops were used in a number of innovative projects with industrial partners such as RATP (the French company operating the Paris subway), Tháles and Renault. The KCP workshops involves a series of three meetings (Elmquist and Segrestin 2009): one for knowledge sharing (phase K), one for the conceptual exploration (phase C) and one to structure the proposal (phase P). The KCP-workshop aims at structuring the exploration of a set innovative concepts and offers a frame work in which to collectively address the tasks. More information can be found in (Hatchuel et al. 2009).

There are differences between the ID-method workshops and the KCP-workshops. In the KCP-workshops there is a strong influence by the organizers as they generate and structure the first concepts from which the connection with the existing domain knowledge is initiated. In the Integral Design workshops the participants of the workshops are more interdependent as they have to generate there own concepts initiators from their combined knowledge represented in the Morphological Overview.

7 Conclusion

At the TU Eindhoven an Integral Design method (ID-method) has been developed. In workshops with experienced professionals a first prototype of the ID-method was developed integrating four key elements: design team, design model, design tool and design setting. Within the ID-method the structured presentation of object-design-knowledge is guided by using morphological charts. The underlying assumption of the method is that the exchange of knowledge of different disciplines will lead to a better shared understanding of the task but at the same time guarantee the benefits of a heterogeneous team to generate a broad variety of solutions. The design method supports knowledge transfer and knowledge creation which stimulates innovation on product and process level.

The ID-method was developed and tested in practice in cooperation with the Dutch society of Architects and the Dutch society of consulting engineers. In 2006 the Institute of Dutch Architects decided, based on the acquired positive results from the evaluations of the workshop participants, to include the ID-method in their Academy for permanent profession development. An ID-method course will be facilitated by the Dutch Society for Building Services Engineers and will start in second half of 2009. Through this the ID-design method stimulates innovation in Dutch building industry on an organizational and cultural level.

Acknowledgement. The Knowledge Centre Buildings and Systems (KCBS TU/e-TNO), Kropman bv and the Foundation 'Stichting Promotie Installatietechniek' (PIT) supported this research.

References

Adems, R.S., Turns, J., Atman, C.: Educating effective engineering designers: the role of reflective practice. Design Studies 24, 275–294 (2003)

van Aken, J.E.: Valid knowledge for professional design of large and complex design processes. Design Studies 26(4), 379–404 (2005)

Bax, T., Trum, H.M.G.J.: A building Process Model according to Domain Theory. In: Design Research in the Netherlands 2000, Bouwstenen 63, Eindhoven University of Technology. Dep. of Architecture, Building and Planning, Eindhoven, pp. 19–30 (2000)

Blessing, L.T.M.: A process-based approach to computer supported engineering design. PhD thesis Universiteit Twente (1994)

Buckingham Shum, S.: Negotiating the Construction and Reconstruction of Organizational Memories. Journal of Universal Computer Science 3, 899–928 (1997)

Elmquist, M., Segrestin, B.: Sustainable innovative design: lessons from the KCP method experimented with an automotive firm. International Journal of Automotive technology and management (2009)

Friedl, G.: Modellering van het ontwerpproces [Dutch; English translation: Modelling of the design process]. PDEng. thesis, Technische Universiteit Eindhoven, Stan Ackermans Instituut, Eindhoven (2000)

Hatchuel, A., Le Masson, P., Weil, B.: Design Theory and Collective Creativity: a Theoretical Framework to evaluate KCP Process. In: ICED 2009, Stanford, August 24-27 (2009)

Hatchuel, A., Weil, B.: A new approach of innovative design: an introduction to C–K theory. In: Proceedings of 14th International Conference on Engineering Design, Stockholm (2003)

Hatchuel, A., Weil, B.: Design as forcing: deepening the foundations of C–K theory. In: Proceedings of 15th International Conference on Engineering Design, Paris (2007)

Hatchuel, A., Weil, B.: C-K design theory: an advanced formulation. Research in Engineering Design 19(4), 181–192 (2009)

Koskela, L., Kagioglou, M.: The Proto-theory of Design: the Method of Analysis of the Ancient Geometers. Strojarstvo 49(1), 45–52 (2007)

Nonaka, I., Takuechi, H.: The knowledge creating company: how Japanese companies create the dynamics of innovations. Oxford University Press, New York (1995)

Pahl, G., Beitz, W., Feldhusen, K., Grote, K.H.: Engineering Design, A Systematic Approach. Translators and Editors Ken Wallace and Luciënne Blessing, 3rd edn. Springer-Verlag, London Limited (2007)

Seppänen, O., van Steenberghe, T., Suur-Uski, T. (eds.): Energy Efficiency in Focus – REHVA workshops at Clima 2007, REHVA Report No.2 (2007)

USP Marketing Consultancy, Faalkosten in de bouw naar hoogtepunt [Dutch; Failure costs in building sector peak], USP Bouwsignalen, Rotterdam (April 11, 2008), `http://www.usp-mc.nl`

Vermaas, P.E., Dorst, K.: On the conceptual framework of John Gero's FBS-model and the prescriptive aims of design methodology. Design studies 28(2), 133–157 (2007)

Wichers Hoeth, A.W., Fleuren, K.G.A.: De bouw moet om [Dutch; English translation: The building sector has to turn round], Stichting Bouwresearch, Rotterdam (2001)

An Evaluative Inquiry of University Innovation Mentor Facilitation of Service Innovation

John Sparrow[1], Krystyna Tarkowski[2], and Michele Mooney[1]

[1] Birmingham City University, Franchise St, Perry Barr, Birmingham B42 2SU
e-mail: john.sparrow@bcu.ac.uk
[2] Coventry and Warwickshire Lifelong Learning Partnership,
Coventry University Technology Park, Puma Way, Coventry, CV1 2TT

Abstract. This study highlights how knowledge transfer can operate through a process consultation approach. Key issues in developing university innovation mentors and supporting their activities in facilitating service innovation are discussed. Significant impact of the approach upon client organisation performance and capability was identified. The value of adopting an evaluative inquiry process to capture and address the emergent challenges of this form of knowledge transfer is highlighted.

1 Background Literature

1.1 Knowledge Transfer and Facilitation

It has long been recognised that helping has two principal goals: i) help clients manage their problems, and ii) help clients become better at helping themselves (Egan, 2006). Evaluations of business support (e.g. Bennett and Robson, 2005) and university-industry knowledge transfer (Perkmann and Walsh, 2007) have explored the impact associated with ‘advice-based’ support. Contrary to the `one off consultancy service' provided by a majority of big consultancies based on a `one solution fits all'-type interventions however, an `end-to-end engagement process' suggests that an intervention process is better suited for SMEs as resources and knowledge can be brokered as problems occur. Perkmann and Walsh (2007) support this argument in saying that:

> “in the context of open innovation, it is particularly the links with high relational involvement that are of interest, as they facilitate the building and maintenance of inter-organizational relationships over a prolonged period of time” (p263).

Entrepreneurial and organisational learning have been found to be key facets of knowledge acquisition and innovation in small firms (Zhang et al, 2006). Coaching

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 345–353.
springerlink.com

and mentoring have been argued to be effective approaches towards entrepreneur development (Thompson and Downing, 2006).

There is therefore an important distinction between an expert notion of consultancy and process consultation. Schein (1995) notes that "from a process consultation perspective, all interventions should be jointly owned by the consultant and the client who is involved at that stage" (p15). Schein (2006) advocates:

> "not expert advice but (1) facilitating the client's own understanding of his or her own problem and (2) teaming up with the client to jointly develop a solution . . . most consultants attempted to recommend expert solutions and most of these solutions were not implemented because they ignored critical factors in the client's situation" (p294).

Process consultants attempt "to release the client's own resources through self-diagnosis and self-interventions" (Gummesson, 1991, p. 32), and Schein (2001) notes:

> "The critical distinguishing features of this inquiry model are 1) that the data come *voluntarily* from the members of the organization because they initiated the process and have something to gain by revealing themselves to the clinician/consultant/researcher, and 2) that the helper consultant actively involves the client in the inquiry process itself not to improve the quality of the data . . . but in order to *improve the quality of the helping process*" (p 190).

The clinical inquiry approach is seen as particularly appropriate for understanding and affecting organisational development in a rapidly changing and dynamic environment (Coghlan, 2003). "The more goal oriented focus of the clinical inquiry approach, assisting firm development over a longer timeframe, when administered with care, can yield greater insights on enterprise restructuring." (Gorton et al, 2005: 50). The emphasis shifts from teaching towards facilitating questioning alongside associated alternative responses (e.g. evaluative, interpretive, supportive, probing and understanding responses (Cook, 2007: 35-38). The Tavistock Consultancy Service (2007) state:

> "The TCS Process Consultancy approach has three core components. Firstly, adopting a *process consultancy style* means helping clients to find their own solutions to their organisational issues. This means that clients retain responsibility for their organisational issues and for the solutions they implement. Secondly, our particular process consultancy approach also involves *working below the surface*, which means that we help clients to identify and work with the dimensions of organisational life that are usually hidden below the surface. Thirdly, our approach uses *systemic thinking* to help clients to analyse the different contextual layers of the organisational system, e.g. individual, group, department, whole organisational system and external environment" (p 1).

University staff have the opportunity to operate as process consultants and facilitate transformational change in client organisations with associated entrepreneurial and organisational learning. Many of the challenges they may face in this regard have not been researched.

1.2 Service Innovation and Innovativeness

Competitive advantage is increasingly based upon dynamic capabilities. Teece et al (1997) highlight responsiveness and innovation, coupled with the management capability to effectively coordinate and redeploy internal and external competences as key. Vang and Zellner (2005) highlight that service innovation can involve new or improved: service or good; process of production or delivery; internal organisation; and/or market innovation and changes in external relations.

Fostering a service innovation evaluation process within organisations has the potential to promote transformational (Kindler, 1976) rather than merely incremental change. According to Kindler (1976:p. 477) transformational change is a variation in kind that involves 'reconceptualization and discontinuity from the initial system'. The ability to be able to respond dynamically to the business environment requires the capacity to absorb external knowledge. Cohen and Levinthal (1989) emphasised that 'a stock of prior knowledge …constitutes the firm's absorptive capacity' (p 569-570). Cohen and Levinthal (1990) note how the ability to evaluate and utilise outside knowledge is largely a function of the level of prior related knowledge, and being able to recognise the value of new information, assimilate it, and apply it to commercial ends. Since this capacity is cumulative 'dynamically self-reinforcing behaviour,' the greater the absorptive capacity, the more sensitised the individual, organisation or region is to evolving opportunities, the greater their aspiration to exploit these opportunities (Kinder and Lancaster, 2001). According to Zahara and George (2002, p.188), absorptive capacity is a unique capability that is embedded in organisational processes and routines. The authors define it as a dynamic capability composed of four distinct organisational capabilities: acquisition, assimilation, transformation and exploitation. Zahara and George (ibid) subdivide 'acquisition' and 'assimilation' as potential absorptive capacity and 'transformation' and 'exploitation' as realised absorptive capacity. Jansen et al (2005) notes how organisational mechanisms associated with coordination capabilities (e.g. cross-functional interfaces, participation in decision making, and job rotation) primarily enhance a unit's potential absorptive capacity. Organisational mechanisms associated with socialisation capabilities (e.g. connectedness and socialisation tactics) primarily increase a unit's realised absorptive capacity**.** There is evidence to suggest that transformation in organisations is sporadic and associated with 'tipping points' in development. Bessant et al (2005) introduce 'Tipping Points' as the key areas where organisations face a sudden and intensive change in one or many of their internal (People Management, Strategy, Formalised Systems, Obtaining Finance and Operational Improvement) or external functions (New Market Entry). The `Tipping Points' model (Bessant et al:

2005) underlines the various areas where a company may encounter the need to change, including people management, strategy, formalized systems, new market entry, obtaining finance or operational improvement. Frequently, companies `tip' at more than one area and don't have the resources or finances to identify the right approach to transform their processes for change. While growth inevitably impacts size, structure and processes, SMEs frequently lack suitable support to prepare for the next stage of their existence.

There is therefore, a need to recognise the relationships between entrepreneurial learning, organisational learning, absorptive capacity, innovativeness, adaptability and agility together with the role of facilitation of these ends. There are a number of key issues in adopting a facilitation approach towards service innovation in a university-industry context. Sparrow et al (in press) highlight how university staff can benefit from explicit training and development in consultancy and change concepts such as knowledge integration and absorptive capacity. The conceptions that university academics and industry can have of the processes and capabilities of universities in knowledge transfer can be quite narrow and traditional (Sparrow et al, 2006). The potential for universities working within organisations upon innovation, tipping points, transformational change and innovativeness has been explored by Sparrow and Tarkowski (2008).

Navigating through these concepts and embracing them within knowledge transfer practice is a big challenge for universities. Approaches towards problematising such issues in ways which create capability is a key challenge. The current paper explores some of the ways in which these issues can be incorporated in universities' support of organisations.

2 Methodology

Birmingham City University was one of five experimental projects funded by HEFCE which aimed to demonstrate the potential benefits to the economy of third-stream-focused HEIs. Fifty BCU academic staff were trained as Innovation Mentors for regional SME, public sector and third sector organisations to enhance their service innovation. The project title was Service by Design (SbD). Encouraging staff to become more aware of consultancy and knowledge transfer principles within this process was sensed to be potentially valuable. *Evaluative inquiry* (Preskill and Torres, 1999) combines action research and evaluation with questioning and debating the value of what people do in organisations through dialogue, reflection, asking questions and clarifying values, beliefs and knowledge with regard to an issue or problem. It is:

> "a means for fostering individual and team learning about complex organizational issues. Evaluative inquiry for organizational learning and change is more than a means to an end; it is more than developing skills that result in increased competence or improved profits. A significant consequence of evaluative inquiry is the fostering of relationships

> among organization members and the diffusion of their learning throughout the organization; it serves as a transfer-of-knowledge process. To that end, evaluative inquiry provides an avenue for individuals' as well as the organization's ongoing growth and development" (p. 18).

Staff engaged in an evaluative inquiry of the preparation for, and delivery of innovation mentoring.

The university approach construed facilitation as knowledge integration (Cook and Brown, 1999) where knowledge of related parties is combined and "generated in" a new context. Furthermore, the effectiveness of such interactions depends in part upon the dynamic capability (Teece and Pisano, 1994) of both parties to internalise and refine such knowledge (i.e. absorptive capacity) in order to maximise transformational change. *Explicit* use of such concepts shaped the approach that the university took towards the knowledge transfer project.

Bejou et al (1998) suggested that trust is a key service consideration. Bennett and Robson (2005) found that SME clients developed different forms of trust with the different agencies that provide them with support and advice. Trust within a counselling, coaching or mentoring context is anchored in the role of the 'consultant' as 'learning facilitator' rather than knowledgeable 'adviser'. Behnia (2008) highlighted the value of research capturing the dynamics of trust relationships.

The evaluative inquiry sought to capture the processes and perceptions of interactions, together with the reflections of mentors upon development needs. In each organisation supported, there was a lead participant. In each instance the participant was empowered to make changes. In terms of the sample of participating organisations, the majority were SMEs, alongside small strategic business units of public sector organisations and some small social enterprises. The small sample size did not permit separate analyses of the three subsectors of organisations.

The Service by Design consultation approach is a five stage process with a view to set a standard suggested process for Innovation Mentors (IMs) to follow with their companies. The five stages involved in the process are: 1. Discover 2. Identify 3.Deploy 4. Implement 5. Evaluate. The 'Discover' stage allows the Innovation Mentors 'to unleash the strengths, weaknesses and potential opportunities of the organisation'. The objectives of the phase are to understand the organisation's context from a service design perspective.

At a 'Discover Meeting' the IMs meet with managers and discuss the organisations service strengths and weaknesses. The 'Discovery' stage also involves a Service Experience Survey (SES) based on a client survey and a Service Capabilities Survey (SCS) based on a staff survey. Further activities within the Discovery stage may involve opportunity workshops and focus groups. At the end of the 'Discovery' stage the IM is expected to submit a 'Discovery report' based on findings and outline areas for further analysis in the 'Identify stage'. The Discovery report is supported by an analysis based on six areas of investigation which are presented in Table 1.

Table 1 The six service elements (Discovery Phase) of the Service by Design process

Business Vision	*Resources*	*Reliability*	*Responsiveness*	*Reassurance*	*Respect*
Does the organisation exhibit a clear, strategic vision? *Do they have a culture of innovation?* *Do they fare well competitively and are they operationally on-track?*	*Is the appearance of the organisation's asset appropriate?* *Is the organisation adequately resourced?* *Does the organisation measure its performance well?*	*How dependable and accurate is the organisation's service?*	*How willing and prompt is the organisation when providing its service?*	*Do people in the organisation appear competent and credible?* *Are they courteous?* *Are the organisation's processes and assets secure?*	*Does the organisation communicate well with, and take care of, its different customers individual needs?* *Are there clear and honest internal communications?*

The 'Identify' stage addresses the best opportunities for service design in the organisation. The IMs need to identify short business cases for areas that need improvement and for opportunities that can be worked on. The 'Identify' stage also involves the selection of an expert team that is closely suited to the opportunity required and which is capable of solving a problem.

The 'Deploy' stage follows on from the 'Identify' stage. This phase involves matching the best opportunities with the appropriate resources within Birmingham City University.

Finally, the Implementation stage is the fourth stage of the process where all resources are put in place and where recommendations have been applied in practice. Following the implementation stage the final stage is the 'Evaluation' stage so that the university-industry engagement allows for continuous improvement.

Facets of clients, mentor development and the mentoring process were considered in analysing observation, interview and questionnaire data associated with the 18 month programme of mentor development, client identification and client support. The researchers undertook initial assessments of the entrepreneurs and organisations and returned to twelve participating organisations between six to nine months after the initial assessment to administer the assessments again and discuss the experience. The structured assessments used were established questionnaires and scales developed by previous researchers. The current paper focuses only upon the assessments related to personal learning (i.e. Hase and Kenyon, 2007), absorptive capacity (i.e. Jansen et al, 2005), incremental/transformational change (i.e. Kindler, 1997), progression in tipping points (i.e. Bessant et al, 2005) and agility & resilience (i.e. American Management Association, 2006). The insights into the role of trust and the sequence of changes within organisations were obtained from the personal interviews with the clients.

3 Analysis and Findings

The ongoing reflections, group discussions, project adaptation and impact evaluation evolved through the evaluative inquiry process. This highlighted the important principle that 'prescriptive' approaches towards mentor development and client support can have shortcomings, and that 'situated' and 'responsive' configuration of support is essential.

The project demonstrated developments in mentor knowledge, skill and confidence in consulting.

The project demonstrated how initial client expectations together with mentor competence in enabling them to see ways forward were key factors in trust development. Facets of reliability, integrity, transparency and benevolence were important process considerations. Sparrow and Tarkowski (2009) in examining the trust relationships more closely, argue that a process of entrepreneurial learning, personal experimentation appear to progress through to organisational change and organisational learning within the process consultation model.

Paired t-tests were used to assess differences in initial and post intervention scores on the structured assessments. Statistically significant ($p<0.05$) changes were found in the client organisations' practices. In terms of *entrepreneurial and organisational learning,* clients questioned their own competence in novel situations significantly less. *Absorptive capacity* was enhanced in that the organisations were more aware of problems of rigid roles and responsibilities, appreciated limitations that they have implementing new products and services, more quickly recognised the usefulness of new external knowledge to existing knowledge, and less laboriously grasped opportunities. In addition, employees were reported to have developed a common language re products/services. There was a statistically significant increase in the extent to which the organisations reported being engaged in *transformational (as opposed to incremental) change*. The encounter progressed the organisations statistically significantly closer to *tipping points* in operations, formalised systems, finance and strategy. In terms of *agility and resilience* the organisations reported having a heightened sense of need to know about new product services changes in the market, questioned the persistence of their employees, had heightened industry awareness and had enhanced agility strategies with an increase in planned use of benchmarking to predict change need.

4 Conclusions

Service innovation can be a powerful catalyst for transformational change. A mentoring (as opposed to expert consulting) model can facilitate innovation but also enhance innovativeness and agility. Evaluative inquiry provided a useful methodology to help the university develop its approach and capability.

References

American Management Association, Agility and Resilience in the Face of Continuous Change, A Global Study of Current Trends and Future Possibilities 2006-2016, American Management Association (2006)

Behnia, B.: Trust Development: A Discussion of Three Approaches and a Proposed Alternative. British Journal of Social Work 38, 1425–1441 (2008)

Bejou, D., Ennew, C.T., Palmer, A.: Trust, ethics, and relationship satisfaction. International Journal of Bank Marketing 16(4), 170–175 (1998)

Bennett, R.J., Robson, P.J.A.: The Advisor-SME Client Relationship: Impact, satisfaction and commitment. Small Business Economics 25, 255–271 (2005)

Bessant, J., Phelps, B., Adams, R.: External Knowledge A review of the literature addressing the role of external knowledge and expertise at key stages of business growth and development, Advanced Institute of Management Research, AIM (2005)

Coghlan, D.: Practitioner research for organizational knowledge: Mechanistic- and organistic-oriented approaches to insider action research. Management Learning 34(4), 451–463 (2003)

Cohen, W.M., Levinthal, D.A.: Innovation and learning: The two faces of R&D. The Economic Journal 99, 397, 569–596 (1989)

Cohen, W.M., Levinthal, D.A.: Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly 35, 128–152 (1990)

Cook, S.: Counselling Style. In: Compendium of Questionnaires and Inventories, vol. 2, pp. 35–38. Gower, Aldershot (2007)

Cook, S.D.N., Brown, J.S.: Bridging epistemologies: The general dance between organizational knowledge and organizational knowing. Organization Science 10(4), 381–400 (1999)

Egan, G.: The Skilled Helper: A Problem-Management and Opportunity Development Approach to Helping, 8th edn. Brooks/Cole, Pacific Grove (2006)

Gorton, M., White, J., Dumitrashko, M.: Applying the Clinical Inquiry Approach to understand and facilitate enterprise restructuring in transitional economies: A Case Study from the Moldovan wine industry. Systemic Practice and Action Research 18(1), 35–52 (2005)

Gummesson, E.: Qualitative Methods in Management Research. Sage, Newbury Park (1991)

Hase, S., Kenyon, C.: Heutagogy: A Child of Complexity Theory. Complexity: An International Journal of Complexity and Education 4(1), 111–118 (2007)

Jansen, J.J.P., Van den Bosch, F.A.J., Volberda, H.W.: Managing Potential and Realized Absorptive Capacity: How do Organizational Antecedents Matter? Academy of Management Journal 48, 999–1015 (2005)

Keskin, H.: Market orientation, learning orientation, and innovation capabilities in SMEs: An extended model. European Journal of Innovation Management 9(4) (2006)

Kinder, A., Lancaster, N.: Building absorptive capacity in a learning region: a social technical model. Science and Public Policy 28(1), 51–67 (2001)

Kindler, H.S.: Two Planning Strategies: Incremental Change and Transformational Change. Group and Organization Management 4, 476–484 (1979)

Lawson, B., Samson, D.: Developing innovation capability in organisations: a dynamic capabilities approach. International Journal of Innovation Management 5(3), 377–400 (2001)

Perkmann, M., Walsh, K.: University-industry relationships and open innovation: Towards a research agenda. International Journal of Management Reviews 9(4), 259–280 (2007)

Preskill, H., Torres, H.: Evaluative Inquiry for Learning in Organizations. Sage, Thousand Oaks (1999)

Schein, E.H.: Process consultation, action research and clinical inquiry: Are they the same? Journal of Managerial Psychology 10(6), 14–19 (1995)

Schein, E.H.: Process Consultation Revisited. Addison-Wesley, Reading (1999)

Schein, E.H.: Clinical Inquiry/Research. In: Reason, P., Bradbury, H. (eds.) Handbook of Action Research, pp. 185–194. Sage, London (2001)

Schein, E.H.: From Brainwashing to Organizational Therapy: A Conceptual and Empirical Journey in Search of 'Systemic' Health and a General Model of Change Dynamics.A Drama in Five Acts. Organization Studies 27(2), 287–301 (2006)

Sparrow, J., Mooney, M., Lancaster, N.: Perceptions of a UK university as a knowledge intensive business service enhancing organizational and regional service innovation. International Journal of Business Innovation and Research 1(1/2), 191–203 (2006)

Sparrow, J., Tarkowski, K.: University-SME collaboration: Facilitating process change in organizations through anticipating 'Tipping Points' in the context of organizational and entrepreneurial learning. Paper presented at ISPIM Open Innovation conference, 19th ISPIM conference - Open Innovation: Creating Products and Services through Collaboration, Tours, France, June 15-18 (2008)

Sparrow, J., Tarkowski, K.: The role of trust in entrepreneurial learning for organisational agility: Findings from a study of university innovation mentors facilitating SME service innovation. Paper presented at the 32nd Institute of Small Business and Entrepreneurship Conference, Novas Centre, Liverpool, November 3-6 (2009)

Sparrow, J., Tarkowski, K., Lancaster, N., Mooney, M.: Evolving knowledge integration and absorptive capacity perspectives on university-industry interaction within a university. Education and Training (in press)

Tavistock Consultancy Service, Change Agent Programme Prospectus 2007/8, Tavistock Consultancy Service (2007)

Teece, D., Pisano, G.: The Dynamic Capability of Firms: An Introduction. Industrial and Corporate Change 3(3) (1994)

Teece, D.J., Pisano, G., Shuen, A.: Dynamic capabilities and strategic management. Strategic Management Journal 18(7), 509–533 (1997)

Thompson, J., Downing, R.: Effective Entrepreneur Enabling – Increasing the Effectiveness of Advising, Coaching and Mentoring Support. Paper presented at the 29th Institute for Small Business and Entrepreneurship Conference, Cardiff, October 31 – November 2 (2006)

Vang, J., Zellner, C.: Introduction to Special Issue on Service Innovation. Industry and Innovation 12(2), 147–152 (2005)

Zahara, S., George, G.: Absorptive capacity: a review, re-conceptualization and extension. Academy of Management Review 27(2), 185–203 (2002)

Zhang, M., Macpherson, A., Jones, O.: Conceptualizing the Learning Process in SMEs: Improving Innovation through External Orientation. International Small Business Journal 24(3), 299–323 (2006)

Knowledge Transfer Aspects of Project Portfolio Management

Vladimir Stantchev[1,2], Marc Roman Franke[3], and Andreas Discher[3]

[1] Berlin Institute of Technology, Berlin, Germany
e-mail: vladimir.stantchev@tu-berlin.de
[2] Fachhochschule für Oekonomie und Management (FOM), Berlin, Germany
[3] BearingPoint GmbH, Frankfurt am Main, Germany

Abstract. Knowledge transfer has a particular relevance for enterprises with large research and development (R&D) departments. Project Portfolio Management (PPM) is a discipline often applied to structure and align R&D activities. Typical functions of such standardized process are project data repository, project assessment, selection, reporting, and portfolio reevaluation. In this work we discuss how PPM can benefit from knowledge transfer activities and suggest some specific knowledge transfer tasks within the PPM process. This enhancement is based on a knowledge and learning strategy and process in the context of PPM. We also evaluate the applicability of these extensions at different stages of the PPM process.

Keywords: knowledge transfer, project portfolio management, evaluation, innovation.

1 Introduction

Knowledge transfer denotes the means by which knowledge (including expertise, skills and capabilities) are transferred from a knowledge-base to those in need of that knowledge. A knowledge base can be a university or college, a research center or a research technology organisation. "Recipients" of knowledge (e.g., a company, a sales department or other organisations) expect to benefit from it.

Knowledge transfer is often regarded as a mean to achieve competitive advantage in an industry [1]. It can be of high value for project landscapes in enterprises with large research and development (R&D) departments and can be regarded as a topic that encompasses the five pillars of knowledge-related artifacts: knowledge and learning objects, processes, strategies, systems, and performance [2]. We regard Project Portfolio Management (PPM) [3] as a promising strategy in this context, together with a set of processes [4]. There

R.J. Howlett (Ed.): Innovation through Knowledge Transfer, SIST 5, pp. 355–367.
springerlink.com

we assessed the applicability of PPM in knowledge-intensive project landscapes, focusing on product development projects in mechanical and plant engineering. Furthermore, we evaluated an assessment framework that we have proposed in [5]. It serves as a set of strategy and processes for knowledge and learning.

There is a significant growth potential for PPM systems [6]. During crises companies focus even more on effective usage of resources within R&D projects. Quality criteria for project selection and priority such as value creation and strategic fit become even more important [3]. While there are a variety of software tools to support PPM, it is often challenging to derive knowledge subjects from a corporate strategy and to specify them in the precision required by a PPM system.

In this work we discuss how PPM can benefit from knowledge transfer activities and suggest some specific knowledge transfer tasks within the PPM process. This enhancement is based on the knowledge and learning strategy and process in the context of PPM that we presented in [4].

1.1 Work Structure

The rest of this work is structured as follows: Section 2 presents the state of the art in the management of project landscapes and the terminology we use. In Section 3 we describe how our assessment framework for such landscapes can facilitate knowledge transfer. In Section 4 we propose several knowledge transfer tasks as part of a best practice process we presented in [5]. In Section 5 we demonstrate the relevance and applicability of the proposed activities and tasks based on key insights from our empirical evaluation. Section 6 contains a summary of our results and outlook on our future research activities.

2 Preliminaries

Portfolio management emerged from the financial theory as a holistic investment approach. It can also be applied to the management of complex project landscapes in an organisation. Portfolio management is implemented within the innovation and product development process, the central component of the product lifecycle management (PLM). PLM itself is a complex lifecycle approach which aims to encompass all processes and activities related to a product.

In this work we propose and assess extensions of PPM in the context of project-, program-, multiproject- and portfolio management (see Fig. 1). These extensions facilitate knowledge transfer tasks within an organisation.

Projects and programs are distinct singular tasks, separated from one another. Each of them is the responsibility of the particular project manager. The simultaneous conduction of many project initiatives often leads to

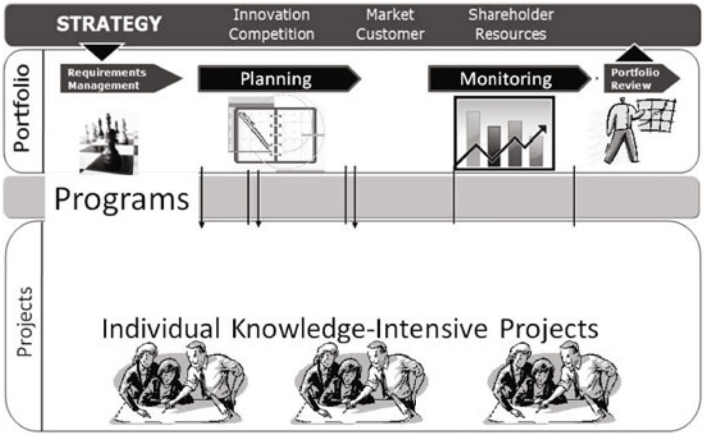


Fig. 1 Knowledge-Intensive Project Landscapes and PPM

conflicts and contradictions within the whole project landscape. Examples are: overlapping knowledge areas, intra-project coordination, resource and competence staffing, as well as budget allocation. A portfolio describes a well defined collection of associated projects and programs. Therefore, the organisation and administration of a portfolio, together with its overall implementation are closely related and interdependent. The components of a research and development portfolio (projects and programs) are generally quantifiable and measurable. Therefore, they can be valuated and prioritized against each other [7]. An optimized global resource allocation requires a holistic view across the whole corporate project landscape. Thereby we should consider all existing portfolios. Overall, we can regard portfolio management as the centralised management of one or several portfolios in terms of identification, prioritisation, authorisation, organisation, realisation and the controlling of its associated projects and programs [5].

We can distinguish three general views of portfolio management in complex project landscapes – organisational, process-oriented, and chart-oriented. The first is an organisational view with regards to its hierarchical administration of projects and the central collection and consolidation of project information, e.g., project goal, budget cost, timeline, resource demand and risk class in superior project portfolios [3]. The second process-related view describes the iterative and cyclic process of selecting and prioritizing new requests and active projects [8]. A third understanding of the word "portfolio" is best described using the multi-axis portfolio chart, which serves as a graphical management decision tool [9]. As a distinct organisational unit, the project and portfolio management office (PMO) serves as a neutral governance instance and is authorised to audit the accuracy of the process compliance.

We can evaluate and measure the degree of excellence in PPM using a maturity model. The Capability Maturity Model Integration [10] (CMMI) is a standard reference that emerged from the world of software engineering processes. Based upon it, the Project Solution Group [1] and the Center for Business Practices [2] have developed and published further models to assess the level of portfolio management maturity. Nevertheless, usage rates of these models can be improved in the future by using knowledge transfer activities.

3 Knowledge Transfer Objectives in Complex Project Landscapes

Knowledge transfer manifests itself in the comparative evaluation of requested project proposals. Finding appropriate criteria to select and prioritize projects is directly linked to knowledge transfer in complex project landscapes. The evaluation of project proposals produces a ranking list. This list serves as an information basis to support the final portfolio decision of accepting or rejecting proposed requests and also to continue or cancel currently running projects. Therefore, an evaluation system should consider all relevant projects, those actively running as well as these prospectively requested. Furthermore, it should cover different project and knowledge categories [11].

3.1 Structuring Knowledge Objectives in Project Requests

A cornerstone of portfolio management is the consistent collection of project requests in a central information repository. The usage of a standard request form for all project types and the introduction of a standardised acceptance and review process allows us to compare the contributions of projects from different knowledge areas. Beside the common project master data (e.g., name, timeline, milestones, demand manager), we need to consider knowledge-related information about implementation risk and strategic values. Furthermore, a definition on a project proposal is often based on a detailed business case. This business case typically requires knowledge transfer from the R&D field in the field of product management and vice versa.

3.2 Effort Estimation and Knowledge Resources

Project budget cost is defined as the projected cost demand that is required while conducting the project during a certain period of time. Compared to an *a priori* estimated planning cost, the once allocated budget is fix and binding. A cost estimation of future R&D projects is a very challenging task and often involves complex methodologies. Examples in the area of software

[1] Project Solution Group: http://www.psgus.com
[2] Center for Business Practices: http://www.cbponline.com

engineering include the Constructive Cost Model (COCOMO II) [12] and use case points (UCP) [13].

Availability of knowledge workers is particularly limited and is often the most direct constraint of a project. Therefore, we have to consider human resources, together with their knowledge and competence profiles during the planning phase of a project. This entails information about expertise, skills and capabilities which is often not formally specified and stored.

3.3 Reflecting Core Knowledge in the Project Landscape

A successful product development project must also follow the overall corporate strategy. Actually, such a project is an implementation step of this strategy. A strategic fit reflects the degree of alignment between enterprise-wide knowledge and learning objectives on the one side, and, on the other side, the currently conducted project activities. Some key factors have already been discussed in [8]. We suggested an even more granular breakdown of the strategic value assessment to several specific knowledge-related driver classes in [4]. These drivers are knowledge-related measures to evaluate the future value of technical products and to forecast future prospects of the product success.

In addition to the proposed knowledge-related drivers of technology, we have to define universally valid drivers of economic value (Business Drivers) in another catalog. Universally valid here means that these drivers are independent from industries, manufacturer of products or service providers. This is also orthogonal to the industry- and project-category-specific technical drivers. We have discussed business drivers such as customer value and growth rate in [5].

3.4 Balancing Knowledge Areas and Risk Areas

The allocation of resources to projects can be regarded as an operationalization of the corporate vision and business strategy. By classifying projects to a strategic bucket according to their knowledge class or category we are essentially expressing the strategic direction of a company. If the corporate mission aims to be positioned as an innovator in the market, the chosen product and development project mix should reflect this. The objective of classifying projects into separate clusters is to be able to define a reasonable evaluation framework for each cluster individually as strategic driver may vary strongly within the respective project type. Knowledge transfer can help to define suitable strategic buckets and a more precise evaluation framework.

Risk is an intrinsic property of every project portfolio decision. Assessing the impact of knowledge-related risks is best practiced as a survey about hierarchically arranged risk categories. Here we can also apply typical risk considerations, such as excess project costs, or failing adherence to schedule. Nevertheless, the main objective is the assessment of risks relating to technical feasibility. This assessment can also be facilitated by knowledge transfer, e.g., experiences from previous projects (company-wide or industry-wide) can be aggregated to provide better estimation results. Furthermore, risk indexes concerning technical and business success factors can also be converted to probabilities (the higher the risk, the less the probability) and combined with financial figures to calculate an overall likelihood of a project's profitability value. This is also a field where knowledge transfer can help.

4 Proposed Knowledge Transfer Tasks

In this section we focus on two aspects of knowledge transfer as related to PPM. The first deals with knowledge transfer activities between scientific research communities and industry, the second is the inclusion of knowledge transfer tasks within the PPM process in an organisation.

4.1 Knowledge Transfer Activities between Research and Academia

Portfolio management is regarded as one of the key activities within innovation management. Authors such as Wheelwright [14], Clarke [15], Cooper [8], and diBenedetto [16] have thoroughly motivated this. There is also a variety of methods these authors have proposed for project selection and portfolio optimisation.

In our work within different industries we have gained the impression that the visibility of this research works there is not optimal. Therefore, we propose (and practice) a more intensive knowledge transfer in this area. This transfer can succeed by using different means. On the one side, conferences and publications with academia-university focus in the area of PPM can help. On the other side, we believe that directly engaging industrial partners is an even better approach. Examples for such engagements are consulting and technology projects, knowledge transfer partnerships (e.g., the UK KTP initiative), as well as surveys and studies with direct contact (e.g., interviews, workshops and discussions).

4.2 Knowledge Transfer Tasks within the PPM Process

We propose the inclusion of several knowledge transfer tasks along the product development process. The process itself consists of the steps: (i) project proposal acceptance, (ii) requirement specification and preliminary organisational activities, (iii) conceptual work on product and process design, (iv) the actual product development including quality management and prototyping, (v) market launch and distribution marketing, (vi) start of series manufacturing (in case of mass products). A *Stage Gate Process* has been developed to provide a generic pattern for structuring, formalising, and thus improving the efficiency of these innovation management and product development tasks [17].

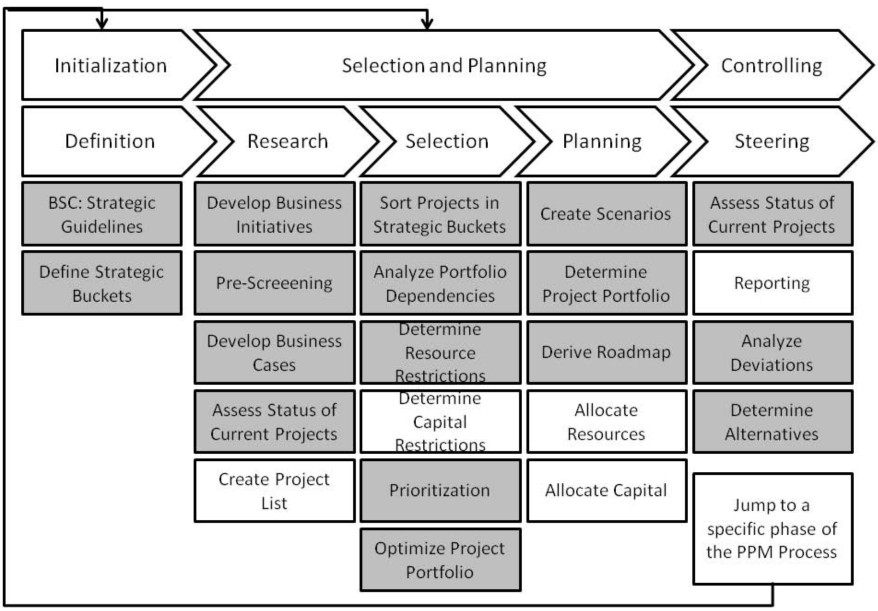


Fig. 2 Knowledge Transfer Areas within the PPM Process

Phases and steps of the PPM process are shown in Fig. 2 (adapted from [5, 4], see there for an explanation of the process steps).

The steps where knowledge transfer tasks can take place are depicted gray in Fig. 2. Due to space limitations we will describe exemplary knowledge transfer tasks within two steps of different phases – *Develop Business Cases* (phase Research) and *Determine Resource Restrictions* (phase Selection).

In the *Develop Business Cases* step we propose the following knowledge transfer tasks: (i) transfer of market research knowledge to project proposal creators, (ii) transfer of product structure knowledge to project proposal creators, (iii) transfer of strategic knowledge to project proposal creators, and (iv) transfer of regulatory and legislative knowledge to project proposal creators.

In the *Determine Resource Restrictions* step we propose the following knowledge transfer tasks: (i) transfer of financial constraints to PMO, (ii) transfer of required competence profiles from R&D to PMO, (iii) transfer of available competence profiles from HR to PMO, and (iv) transfer of still required competence profiles from R&D to HR.

5 Evaluation

To support our idea that better knowledge transfer activities in the area of PPM and the inclusion of specific tasks within the PPM process will result in a better portfolio management we evaluated it using several empirical and experimental methods. In this section we present some key results from one empirical evaluation (design study).

5.1 Empirical Evaluation

A key objective of our empirical evaluation is the verification of our claim that a higher maturity in PPM corresponds to a better performance in project development. We conducted our survey with a focus group from companies in the areas of plant engineering, automotive and high tech. In our survey we use the methodology presented in [18]. We are conducting the verification for every dimension of our maturity model – management, governance, process, system, resource management, and social aspects. We assess quantitative and qualitative parameters during the survey to demonstrate the verification. This allows us to more clearly establish correlations between PPM maturity and project success. Fig. 3 shows the relevance of PPM as determinded by our empirical evaluation – more than 90% of the respondends consider the recommendations of the PPM process highly relevant to the actual portfolio decision.

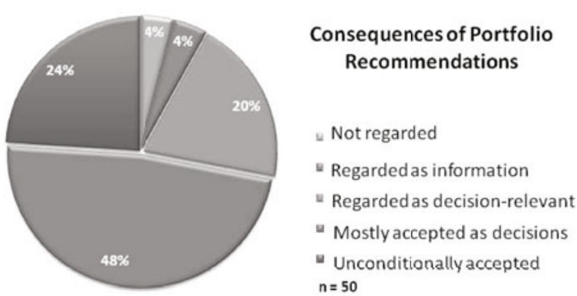


Fig. 3 Acceptance of Results of the PPM Process in the Portfolio Decision

To support our claim that there is need for more knowledge transfer activities between research organizations and industry we evaluated the usage of methods for project selection and portfolio optimization in our focus group.

Fig. 4 shows the aggregated results. The respondents had to select from a list and mark every method they apply in their PPM process. Most often used "methods" are *joint coordination*, *urgent priority* (used by more than 80% of respondents), and *emotion / intuition / experience* (used by more than 70% of respondents). These are generally not regarded as methods by portfolio management research. Some mainstream methods (*bubble charts, scenario technique, scorecards, project dependability analysis, and sensitivity analysis*) are used by less than 50% of respondents, while other methods (e.g., *option value theory*) are rarely mentioned at all. These findings corroborate our thesis that there is a substantial potential for knowledge transfer activties in the area of application of such methods.

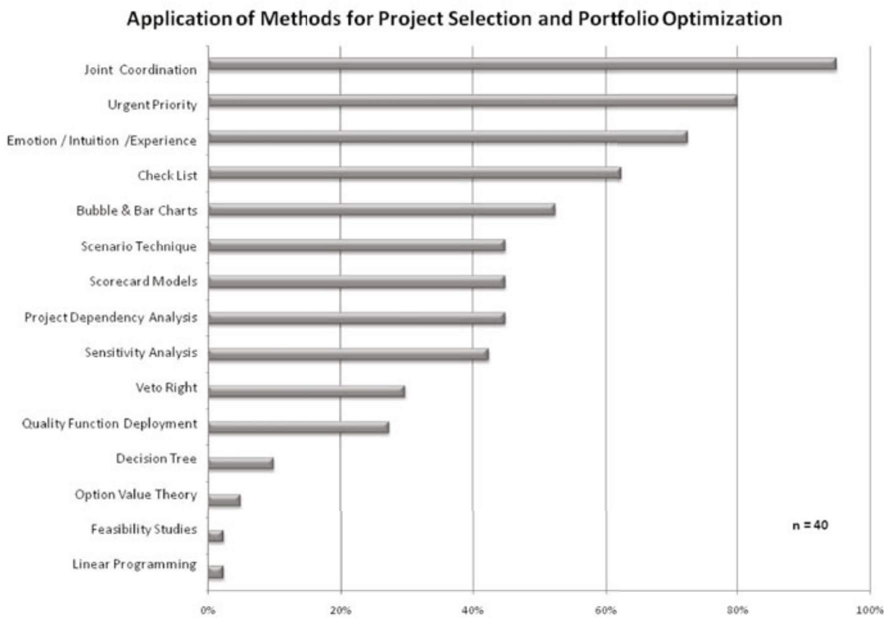


Fig. 4 Application of Methods for Project Selection and Portfolio Optimization

Fig. 5 shows the decision criteria for project investments that our respondents most commonly considered. It shows that almost all considered criteria can benefit from our proposed knowledge transfer tasks in the step *Develop Business Cases*. Examples are: customer needs, strategy fit, innovation / technology, risk, market attractiveness, as well as assortment fit.

While Return On Investment (ROI) was most commonly used as a decision criterion, it also can benefit from knowledge transfer activities, as it typically denotes the *expected* ROI from a given project investment. In this case, knowledge transfer activities between research and industry can provide better estimation and measurement methods. On the one side, results from market research activities can optimize the measurement of current and the estimation of future returns. On the other side, results from research in the area of mathematics, computer science and engineering can contribute to a better cost and effort estimation for a particular development project.

Fig. 5 Most Commonly used Criteria for Decision of Project Investments

Another aspect of our evaluation regarded the usage of software tools to support knowledge transfer within PPM. Fig. 6 shows an overview of results. One key insight is that missing integration and applications that do not cover the process completely are considered by the respondents as the main obstacles for more advanced applications in the context of PPM.

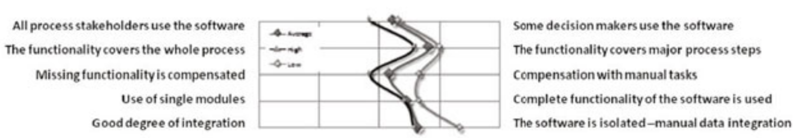


Fig. 6 Software Usage in PPM

The superordinate goal of our research is the definition and evaluation of a holistic maturity model for PPM in knowledge-intensive project landscapes. Fig. 7 shows the aggregated view of maturity levels of all respondents in the six different dimensions – management, governance, process, systems, resource management, and social aspects. We have recorded comparatively low levels in the dimensions *systems* and *resource management*. They reflect a significant gap concerning knowledge transfer within PPM - the high requirements from the areas of management, governance and process are not met from existing software systems. This is an area where knowledge transfer between researchers and software vendors can be of high importance.

Furthermore, competence and knowledge profiles of the personnel resources are rarely considered during resource planning. This is a direct consequence of missing knowledge transfer tasks in this area and can be addressed by the tasks we proposed in Section 4.

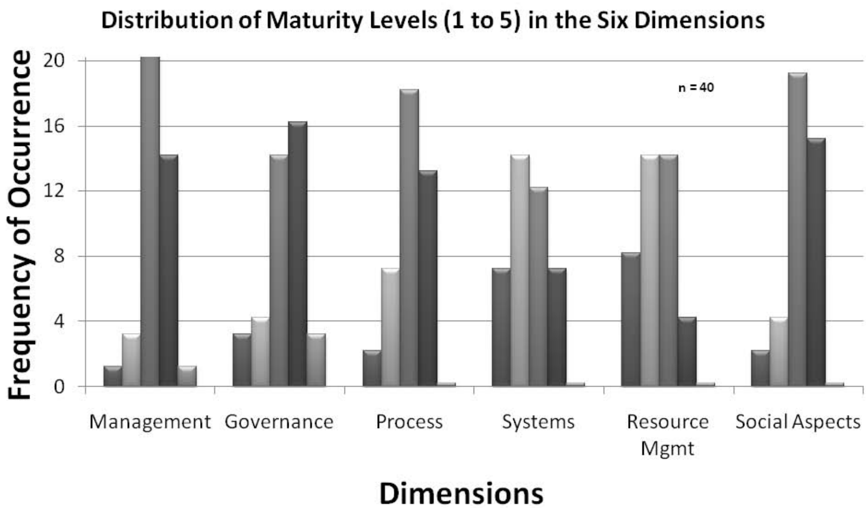


Fig. 7 Maturity Levels of the Respondents (Bars in Every Dimension Denote the Occurrence of a Certain Maturity Level, e.g., 22 Respondents Have a Maturity Level of 3 in the Dimension "Management")

6 Conclusion and Outlook

Project portfolio management can greatly benefit from knowledge transfer activities. These can be tasks within the process of portfolio management itself, as well as knowledge transfer between the research community and practitioners. In this work we proposed such activities in the field of research-industry cooperation and also suggested the inclusion of specific knowledge transfer tasks within the PPM process. Furthermore, we provided empirical results that support our suggestions. Our future research activities are focused in the area of suitable systems for knowledge and learning, as well as in the research of inter-organisational aspects of project portfolio management and knowledge transfer topics in this field.

References

1. Argote, L., Ingram, P.: Knowledge transfer: A basis for competitive advantage in firms. Organizational Behavior and Human Decision Processes 82(1), 150–169 (2000)
2. Lytras, M.D., Sicilia, M.A.: The Knowledge Society: a manifesto for knowledge and learning. International Journal of Knowledge and Learning, 1, 1(2), 1–11 (2005)
3. Rajegopal, S., Waller, J., McGuin, P.: Project Portfolio Management: Leading the Corporate Vision. Macmillan, Palgrave (2007)
4. Stantchev, V., Franke, M.R.: Managing project landscapes in knowledge-based enterprises. In: Best Practices for the Knowledge Society - Knowledge, Learning, Development and Technology for All; Proceedings of the Second World Summit on the Knowledge Society - WSKS 2009. Springer Communications in Computer and Information Science (CCIS), vol. 49. Springer, Heidelberg (2009)
5. Stantchev, V., Franke, M.-R., Discher, A.: Project Portfolio Management Systems: Business Services and Web Services. In: ICIW 2009: Proceedings of the 2009 Fourth International Conference on Internet and Web Applications and Services, pp. 171–176. IEEE Computer Society, Los Alamitos (2009)
6. Dammer, H., Gemünden, H.G., Schott, E., Campana, C.: Die gelebte Projektorganisation: Das Management von Projektlandschaften. In: GPM Deutsche Gesellschaft für Projektmanagement eV (Hrsg.): Projektmanagement aktuell. Ausgabe, vol. 2, pp. 16–23 (2005)
7. The Standard for Portfolio Management. The Project Management Institute, Newton Square, PA (2006)
8. Cooper, R.G., Edgett, S.J.: Ten ways to make better portfolio and project selection decisions. Technical report, Ancaster, Ontario, Canade (2007)
9. Pepels, W.: Produktmanagement: Produktinnovation, Markenpolitik, Programmplanung, Prozessorganisation. Oldenbourg Wissenschaftsverlag (2006)
10. Paulk, M.C., Weber, C.V., Garcia, S.M., Chrissis, M.B., Bush, M.: Key Practices of the Capability Maturity Model SM, Version 1.1. Software Engineering Institute, CMU/SEI-93-TR-25 (February 1993)
11. Kunz, C.: Strategisches Multiprojektmanagement: Konzeption, Methode und Strukturen. Deutscher Universitätsverlag (2007)
12. Boehm, B.W., Abts, C., Brown, A.W., Chulani, S., Clark, B.K., Horowitz, E., Madachy, R., Reifer, D.J., Steece, B.: Software Cost Estimation with Cocomo II with Cdrom. Prentice Hall PTR, Upper Saddle River (2000)
13. Kusumoto, S., Matukawa, F., Inoue, K., Hanabusa, S., Maegawa, Y.: Estimating effort by use case points: method, tool and case study. In: Proceedings of 10th International Symposium on Software Metrics, September 2004, pp. 292–299 (2004)
14. Wheelwright, S.C.: Strategy, Management, and Strategic Planning Approaches. Interfaces 14(1), 19–33 (1984)
15. Clarke, R.G., de Silva, H., Sapra, S.: Toward More Information-Efficient Portfolios. The Journal of Portfolio Management (Fall 2004)

16. Calantone, R.J., Benedetto, C.A., Schmidt, J.B.: Using the Analytic Hierarchy Process in New Product Screening. An International Publication of the Product Development & Management Association 16(1), 65–76 (1999)
17. Cooper, R.G., Edgett, S.J., Kleinschmidt, E.J.: Portfolio Management for New Products. Perseus Books, Cambridge (2001)
18. Banker, R.D., Bardhan, I., Asdemir, O.: Understanding the impact of collaboration software on product design and development. Info. Sys. Research 17(4), 352–373 (2006)

Author Index