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SMART INNOVATION, SYSTEMS AND TECHNOLOGIES ■ 5

Innovation through Knowledge Transfer

Springer

Smart Innovation, Systems and Technologies 5

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ISBN 978-3-642-14593-3

Robert James Howlett (Ed.)

Innovation through Knowledge Transfer

Springer

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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
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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

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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.

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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.
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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

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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.
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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.

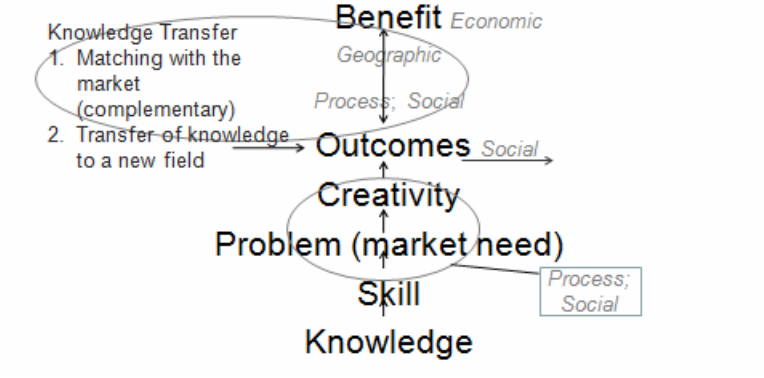

Fig. 1 Components of Innovation and Knowledge Transfer with related research areas

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

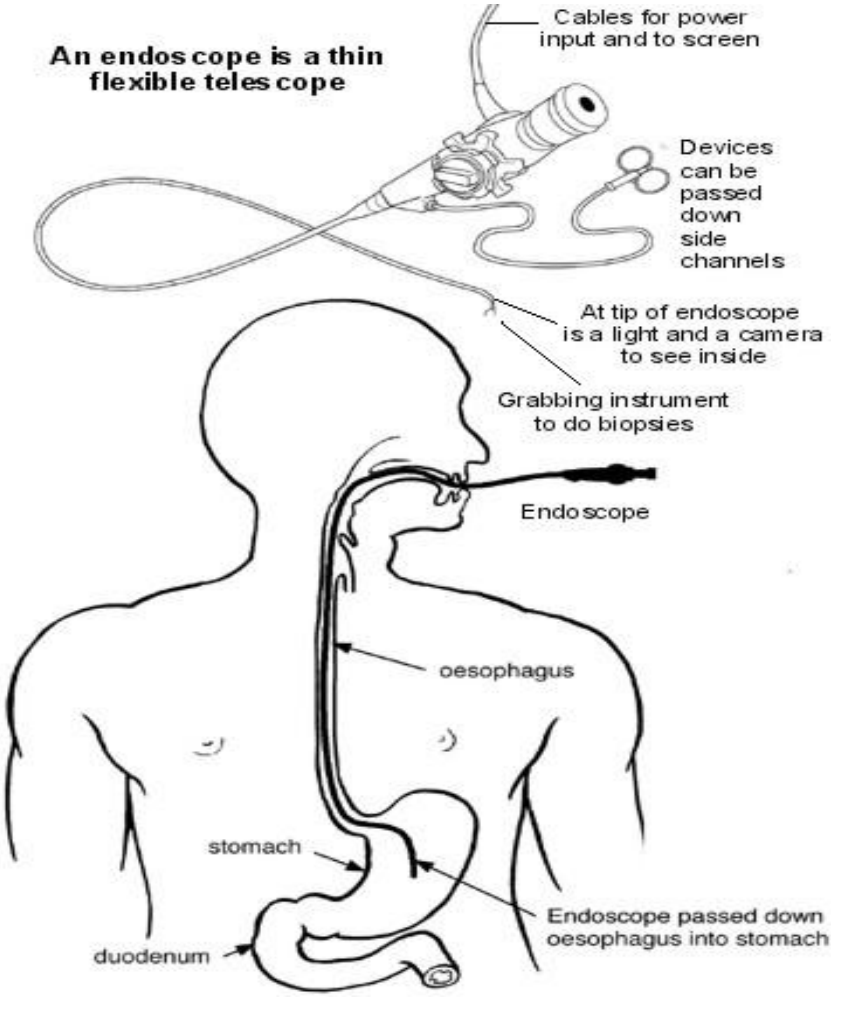

Fig. 2 A modern endoscope

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