# Knowledge and technology transfer from universities to industries: a case study approach from the built environment field

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# Knowledge and Technology Transfer from Universities to Industries: a Case Study Approach from the Built Environment Field*

## Üniversitelerden endüstriye bilgi ve teknoloji transferi: Şehircilik ve mimarlık alanından bir uygulama

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### Özet

Birleşik Krallık'ta, bilgi toplumu ve bilgi tabanlı ekonomiye geçiş önemli politik hedefler arasındadır. Bu politikanın bir uzantısı olarak Bilgi ve Teknoloji Transfer programı üniversiteler ve özel sektör kurumları arasındaki bilgi ve teknoloji alışverişini ve dayanışmayı sağlamak, işbirliğini ve inovasyonu geliştirmek ve şirketleri daha verimli, kendi sektörlerinde daha etkin bilgi tabanlı kuruluşlar haline getirmek amacıyla düzenlenmiş bir programdır. Bu makale, Bilgi ve Teknoloji Transfer Ortaklığı (*Knowledge Transfer Partnership*, KTP) programı altında, Salford Üniversitesi ve özel bir mimarlık şirketi arasında yapılmış olan, şirketin yapısal durumunu iyileştirmek, verimliliğini önemli ölçüde artırmak, iş kapasitesi ile bilgi ve teknoloji altyapısını geliştirmek için yapılan Bina Bilgileri Modelleme (*Building Information Modelling*, BIM) uygulama (*BIM implementation*) projesini ve elde edilen veri ve bulguları açıklayacaktır. Bina bilgileri modelleme, takım çalışmasını ve bilgi alışverişini artırmak, inşaat projelerinde çalışanlar arasındaki parçalı ve kopuk çalışma yapısını, bunun getirdiği problemleri ve verimsizliği gideren, nesne (kapı, pencere, duvar, vs,) tabanlı yeni bir çalışma yöntemidir. Akıllı dizayn üretimi, daha ucuz fakat daha kaliteli dizayn ve inşaat üretilmesini sağlayan BIM tabanlı çalışma sistemi inşaat sektöründeki CAD odaklı çalışma yönteminin yerini almaya başlamıştır. Bu bilgi ve teknoloji transfer projesinin üniversiteye olan katkıları (araştırma/geliştirme ve ders programlarının güncellenmesi) ile söz konusu şirketin iş verimliliği ve kapasitesinin artırılmasına yönelik katkıları da, araştırma metodu olarak örnek olay (*case study*) yöntemi uygulanan bu makalede açıklanmıştır.

**Anahtar sözcükler:** Bilgi ve teknoloji transfer ortaklığı, bina bilgi modelleme sistemi, mimarlık ve sektörü, verimsiz süreçlerin giderilmesi.

### Abstract

Enabling knowledge societies and knowledge based economies is a key policy in the UK. Knowledge transfer partnership (KTP) scheme initiated by the Technology Strategy Board is a pathway for collaboration and partnerships between higher education institutions and companies to transfer innovative knowledge based solutions from universities to businesses in order to equip them with the leading edge knowledge and technology infrastructure for sustainable long term competitive advantages in both national and international market. The paper explains a KTP project between the University of Salford and John McCall Architects (JMA) in Liverpool in the UK that aimed to identify, map and re-engineer JMA's strategic and operational change processes through lean thinking and the implementation of building information modelling (BIM), which is a foundational tool for implementing an efficient process and invariably leads to lean-orientated, team based approach to design and construction by enabling the intelligent interrogation of designs; provide a quicker and cheaper design production; better coordination of documentation; more effective change control; less repetition of processes; a better quality constructed product; and improved communication both for JMA and across the supply chain whereas it provided opportunity to increase business relevance of knowledge based research and teaching for the higher education. Case study approach is employed in this paper and the KTP project is assessed for i) how it helped in improving JMA's knowledge and technology capacity in conducting their practice, and, ii) how it helped the university in improving its knowledge based research and teaching.

**Key words:** Building information modelling, design and construction, knowledge transfer partnership, lean process improvement, technology transfer.

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Knowledge economy and society has contemporarily been an imperative subject in scientific, societal and political arena. Regeneration, for example, is seen as the vehicle to transform the cities from industrial age to knowledge age in order to create more sustainable communities and stronger economies with knowledge and technology led competitive advantages.

Economic policies to unleash the latent or internal potential of cities can be split into four related categories (Jones and Evans, 2008):

- Improving the knowledge base
- Encouraging enterprise
- Education and training
- Empowering local businesses

The UK government embraced the idea of the knowledge based economy into its agenda (DTI, 1998) and argues that all businesses will have to marshal their knowledge and skills to satisfy customers, exploit market opportunities and meet society's aspirations for better environment. Two ways in which the current UK policy has attempted to harness high value, knowledge based industries include encouraging links between universities and industry and cluster policy (Jones and Evans, 2008). The potential economic benefit is considerable, with the creation of knowledge based industries. Many cities are seeking to develop and attract these types of new technology through expanding the higher education sector and encouraging knowledge transfer between universities and industries.

While universities can graduate students with required knowledge and skills for the knowledge base economy, they can also transfer the leading edge knowledge and skills generated within universities to bussiness, through collaborative researches with companies to increase their capacity to attain better position and competitive advantages in their business and aligning themselves with the requirements of the knowledge base economy.

In the following section, the paper explains the Knowledge Transfer Partnership (KTP) programme initiated by TSB (Technology Strategy Board) in the UK between academia and business and how successful it is in reaching its range of objectives related to the government policies about encouraging university and industry collaboration.

## What is Knowledge Transfer Partnership?

Knowledge transfer partnership is a leading programme helping businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK universities' knowledge and technology base. At the same time, it also helps to increase the business relevance of knowledge base research and teaching for the academic institutions (http://www.ktponline.org.uk/). That is to say, KTPs are projects between universities and companies through which academia share knowledge and assist in the development of the industry. The Lambert Review of Business-University Collaboration acknowledges that the Government's funding (in the UK) of knowledge transfer helped to bring innovations into businesses, generated culture change and increased capacity to engage with business that delivers results (Lambert, 2003). Businesses need to develop efficient processes, using the cutting edge tools, technologies and techniques available. Collaboration via KTP also creates an invaluable opportunity to develop high quality, accurate educational material for courses at the universities in both undergraduate and postgraduate levels (Coates et al., 2011).

The KTP projects are 65% Government funded and 35% company funded partnerships. There are three main objectives of a KTP:

- To facilitate the transfer of technology and the spread of technical and business skills
- To stimulate and enhance business relevant research and training undertaken by the knowledge base
- To provide company based training for KTP associates to enhance their business and specialist skills

Both academia and business have something to contribute and gain in this commensurate approach to knowledge development. Knowledge transfer seeks to organize, create, capture or distribute knowledge and ensure its availability for the future users (Coates et al., 2011). This concept of knowledge sharing forms the basis of the KTP schema. Using the knowledge gained from the KTP, universities can develop course material. The mechanism of knowledge exchange which takes place as part of a knowledge transfer partnership is illustrated in Figure 1, which is developed from the KTP project undertaken between the University of Salford and John McCall Architects (JMA) to identify, map and re-engineer JMA's strategic and operational change processes through Lean thinking and the implementation of Building Information Modelling (BIM) (Arayici et al., 2011).

For example, in the case of KTP project about the BIM implementation between Salford University and John McCall Architects (JMA), academia should conceive the BIM context both from business and academic perspectives. This knowledge and perception need to extend to a clear prediction of the skills that the business would require from the future university graduates. This knowledge then needs to be integrated into existing and new course offerings.

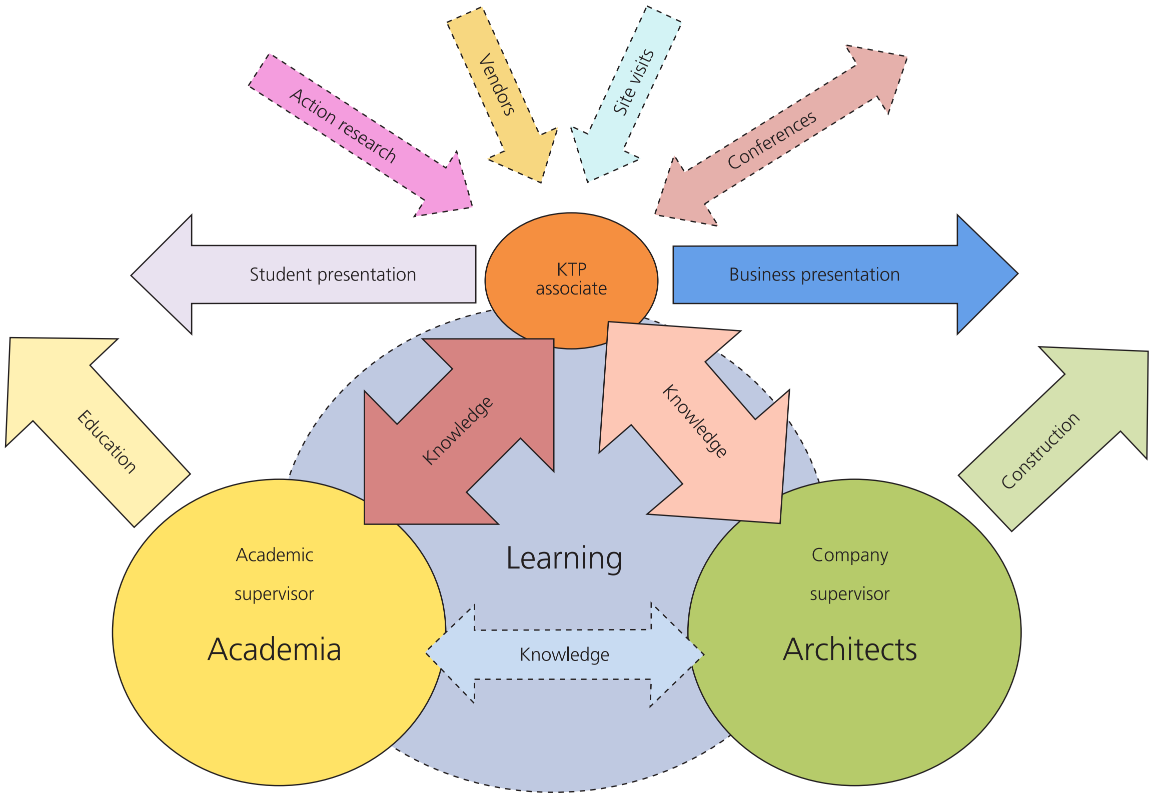


**Figure 1.** KTP knowledge and technology transfer schema

Companies such as JMA face many challenges when adopting BIM. Firstly they need to become sufficiently informed of current technology and concepts to develop an appropriate plan of action. Secondly companies need to have a good understanding of their existing processes to ensure new methods and systems to be effectively and beneficially integrated. It is particularly important to understand what gives the company its unique competitive advantage. This should be maintained through innovation. Furthermore, companies need to develop a vision for their future and gain appropriate support for the vision.

## The Knowledge Transfer Partnership Project with JMA

John McCall Architects was established in 1991 in Liverpool in the UK, focusing primarily on social housing and regeneration, private housing and individual homes and large extensions. JMA works with many stakeholders from design to building construction process and the associated information is very fragmented. Projects in which JMA are involved includes many stakeholders and requires considerable interoperability of documentation and dynamic information.

Historically JMA used 2D CAD tool since 1991. All the company staff excluding the two administration staff had access to this tool and their range of skills varies from proficiency to advanced and expert. However, their current architectural practice with this 2D CAD tool brings about some inefficiency such as timescales, deadline pressures, duplications, lead times, lack of continuity in the supply chain, over processing, reworking, overproduction, conveyance, distractive parallel tasks, reliability of data and plan predictability, lack of rigorous design process, lack of effective design management and communication.

Thus, in line with the lean principles, new tools and processes needed to be thoroughly tested before they are integrated into the company's production system. The company strategically used the lean principles to improve its capacity for i) greater integration and collaboration with other disciplines in the production process, ii) adopting technology change to provide a more effective business process, iii) effective intelligent real time response and iv) moving into related building sektörs. At strategic level, lean principles (Liker, 2003; Koskela, 2003) which are i) Eliminate Waste, ii) Increase Feedback, iii) Delay Decision, iv) Deliver Fast, v) Build Integrity In, vi) Empower the Team and vii) See the Whole were utilized and they formed the seven pillars of the BIM implementation strategy.

Although the company staff had no practical understanding and awareness of BIM in the company at the beginning of the project, some senior managers of the company had some visionary understanding of BIM for investment in order to attain competitive advantages and better position in the market place and providing sustainable green design solutions.

### The Construction Industry and BIM

Construction projects need to be completed in a multidisciplinary environment. Severe issues about data acquisition and management arise during the design and construction management due to the complexity, uncertainty and ambiguity. Further, the construction industry is under pressure to provide value for money, sustainable design and construction and environmentally friendly maintenance of buildings (Eastman et al., 2008).

There is enough evidence to suggest the architectural profession is beginning to come under pressure to adopt BIM too. This information management technology is becoming matured and commercially available after many research projects conducted in this area in the last 20 years. However it is only the last few years, building owners are becoming aware that BIM promises to make the design, construction and operation of buildings much more streamlined and efficient. Owners are starting to enforce their architects and other design professionals, construction managers and construction companies to adopt BIM. This trend gained enormous momentum when the General Services Administration (GSA) of USA announced that BIM is a mandated requirement for public property projects starting in 2006 (US-GSA, 2008). Many other similar uptakes from Europe and Australasia have followed (Mihindu and Arayici, 2008) such as Finland and Denmark.

BIM can be defined as the use of the information and communication technologies to streamline the building lifecycle processes to provide a safer and more productive environment for its occupants, and to assert the least possible environmental impact from its existence, and to be more operationally efficient for its owners throughout the building lifecycle. In other words, it is the utilization of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders. It is a methodology to integrate digital descriptions of all the building objects and their relationships to others in a precise manner, so that stakeholders can query, simulate and estimate activities and their effects of the building process as a lifecycle entity. Therefore, BIM can provide the required valued judgments that create more sustainable infrastructures, which satisfy their owners and occupants (Succar, 2009).

BIM is a foundational tool for a team based lean design approach. It can enable the intelligent interrogation of design; provide a quicker and cheaper design production; better coordination of documentation; more effective change control; less repetition of processes; a better quality constructed product; and improved communication both for the design practice and across the construction supply chain. Although BIM has been implemented by few large design and construction practices, it is not widely (if at all) used by SMEs (Small, Medium Enterprises). Besides, implementation of BIM systems through lean design process brings changes and new challenges for stakeholders. Thus, this paper discusses BIM implementation with lean thinking in design via the KTP project with JMA in Liverpool within the knowledge and technology transfer context.

It is stated that the progression from pen to Computer Aided Design was evolution where now CAD to BIM is a revolution. The objective at the end of a manual drawing process and of a CAD drawing process is pretty much the same. However, the end of BIM modelling process is completely different and the ability to extract drawings from the model that mimic those produced manually or by CAD is relatively trivial part of BIM capabilities. Rather than simply representing form, i.e., product representation as in the case of manual and CAD based drawings, BIM is able to model both product and process. BIM is therefore one of most promising development in the architecture, engineering and construction industries. Because BIM is a revolutionary technology, people are just beginning to learn how to use it.

BIM thus represents a step change which has significant impacts on how the construction industry practices including design, construction and building maintenance phases while it has also impact in higher education on what we can do, how we can do and therefore how we teach students of the architecture, construction and engineering fields. Because the final design alternative exists as a set of specified 3D objects with associated properties, BIM reduces errors of design, improve design quality, shortens construction time, significantly reduces building lifecycle costs, provides a platform for interoperability, information share and exchange, and enables the integrated project delivery.

## The BIM Adoption and Implementation Process in the KTP Project

The project aimed to enable the growth of JMA by integrating and reengineering its processes and through establishing a niche capability in BIM, both with its clients and through the supply chain. BIM implementation and adoption is planned through the stages summarized in Table 1.

It aimed not only to implement BIM and therefore assess the degree of the successful implementation, but rather to position this within the context of value-added offerings that can help the company place itself at the high-end knowledge-based terrain of the construction sector. Therefore, it adopts a socio-technical view for BIM adoption in that it does not only consider the implementation of technology but also considers the socio-cultural environment that provides the context for its implementation.

At the outset of the project, a diagnostic study carried out to capture requirements and knowledge needed at the outset ( Figure 2) through the requirements engineering methods such as soft system methodology (Checkland et al., 2006) and contextual design technique (Beyer and Holtzblatt, 1998).

The BIM adoption methodology uses the action research oriented qualitative and quantitative research for discovery, comparison, and experimentation. Hence the KTP project with JMA provides also an environment for "learning by doing" (Coghlan and Brannick, 2001) because it is simply a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out (Boshyk and Dilworth, 2009).

As a result of the BIM technology adoption, efficiency gains are achieved through the piloting and the actual design projects undertaken by JMA during the KTP and the design process is improved and streamlined through the elimination of wastes and value generation. These efficiency gains for the company are briefly highlighted in the following section.

**Table 1.** BIM implementation approach for JMA's design practice

| |
|---|
| **Stage 1:** Detail Review and Analysis of Current Practice |
| Production of current process flowcharts |
| Soft system analysis |
| Review of IT systems |
| Stakeholder review and analysis |
| Identification of competitive advantages from BIM implementation |
| **Stage 2:** Identification of Efficiency gains from BIM implementation |
| Efficiency gains from BIM adoption |
| **Stage 3:** Design of new business processes and technology adoption path |
| Production of detail strategies |
| Documentation of lean processes and procedures |
| Identification of key evaluation metrics |
| Documentation of BIM implementation plan |
| **Stage 4:** Implementation & roll-out of BIM |
| Piloting BIM on three different projects (past, current, and future) |
| Training the JMA staff and stakeholders |
| Devising and improving company wide capabilities |
| Documentation and integration of processes and procedures |
| **Stage 5:** Project review, dissemination and integration into strategy plan |
| Sustaining new products and processing offerings |
| Evaluation and dissemination of the project |

### *Recognized Benefits and Efficiency Gains for the Company from the KTP*

The KTP enabled JMA to establish itself as the vanguard of BIM application giving them a competitive edge because BIM enables the intelligent interrogation of designs; provide a quicker and cheaper design production; better co-ordination of documentation; more effective change control; less repetition in the design process; a better quality constructed product; and improved communication both for JMA and across the supply chain. Therefore, it had internally big impact to gain efficiencies and effectiveness as the adoption established the required capacity internally as follows:

- Maintaining lessons learned and experiences from the past projects as company asset
- Integration of internal Information Technology (IT) systems of knowledge management such as marketing, finance, administration with BIM based design projects
- Ability of top management for project progress monitoring
- Effective reuse of information
- Consistent exchange of information within JMA
- Quality, time and cost efficiency via automation such as drawings, automatic quantity take-off, instant generation of VR models, discovering design errors and conflict analysis, information sharing and exchange, greater flexibility to satisfy customers, simultaneous work by the staff in the company
- Consistency across the drawing sets

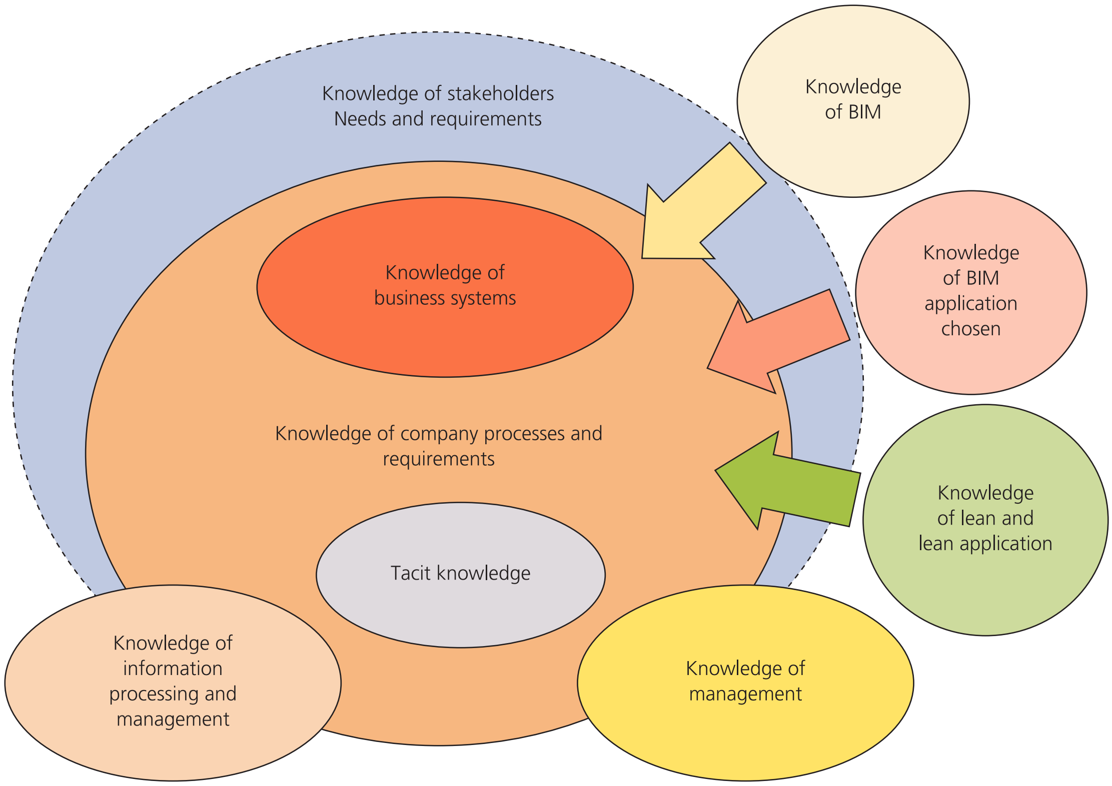


**Figure 2.** Knowledge and requirements needed for the successful conduct of the KTP

- Automation of e-mails and finding consultant offices via the Knowledge Management (KM) system that facilitates faster access time to useful information, automatically includes project information in e-mail, and links post-codes to maps.
- Integration with energy assessment tools for "Code for Sustainable Homes" standards
- Lean process of conceptual design and detailed design development via BIM of the housing design projects
- Effective design and technical review of all the projects in order to avoid potential problems arising from mistakes in the future
- Leading to standardised lean design process across the company

It also provided a clearer vision and roadmap with detailed strategies, methods and techniques for successful BIM implementation. Furthermore, based on the current findings and optimistic behaviour and culture evolved during the project, it re-engineered the operational and IT processes and broadened the knowledge of existing staff up in the company while increasing the awareness of the external partners working with JMA in the supply chain. This is because the BIM adoption and implementation approach was as much about people and processes as it is about technology to i) engage people in the adoption, ii) to ensure that people's skills and understanding increases and companies building up their capacities, iii) to apply successful change management strategies, iv) to diminish any potential resistance to change (Arayici et al., 2011b).

### *Recognized Benefits and Efficiency Gains for the University from the KTP*

Overall expected benefits of such KTP projects are to i) develop business relevant teaching and research material, ii) apply knowledge and expertise to important business problems, iii) identify new research themes and undergraduate and postgraduate projects (www.ktponline.org.uk/). The KTP project has indeed provided such benefits to the academics for higher education use. For examples, the followings generated from the KTP project can be used in higher education for teaching and research purposes. The deliverables produced in the KTP for higher education use were:

- Flow charts and process diagrams of existing processes
- A SWOT analysis of the company
- PowerPoint presentations developed to show the benefits of BIM to all the different disciplines within the design and construction process
- PowerPoint presentations explaining lean principles and their application to architectural practice
- Development and use of systematic BIM authoring tool review process and presentations
- Documentation of lean efficiency gains and their achievement from BIM
- Development of a knowledge management database system to structure information residing outside of the BIM model
- Observation and awareness of the issues concerning the piloting projects, which leads to further research project development
- The training methods and material developed to train members of staff at JMA
- Presentation and publications in conferences and scientific journals
- Contribution to the School of the Built Environment in the national Research Framework Exercise of the UK universities.
- Identify new research themes and undergraduate and post graduate projects

From these deliverables the university can develop material for new and existing courses as illustrated in Figure 3.

The diagram in Figure 3 shows how KTPs can innovatively contribute to universities in updating their knowledge and technology assets for teaching graduate students required for knowledge economy and society. At the same time, it has also led to further follow up research activities such as:

- Optimisation of architectural practice via BIM adoption with lean thinking
- Integration of BIM with knowledge management
- Integration of BIM with system dynamics for retrofitting simulation
- Integration of BIM with Geographical Information Systems (GIS) for smart grid modelling for efficient energy distribution

## Conclusion

The vehicle of the KTP allowed academics to acquire more direct experience about the issues and challenges when transitioning to BIM oriented practice. Academics were able to see what is happening in the business setting and were able to interrogate those directly involved in the business. This gives an immediacy and accuracy to the insights gained.

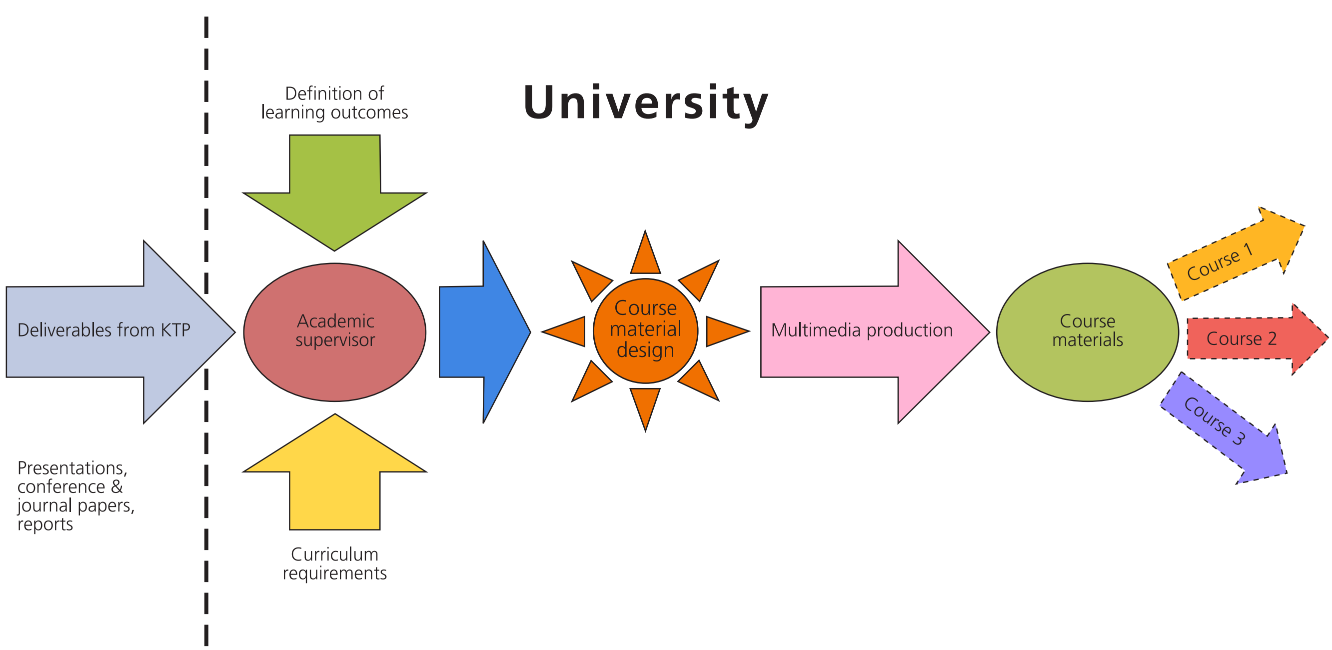


**Figure 3.** Process of course material development from KTPs

Numerous deliverables produced from the KTP can be used for teaching and research by the university. It is also considered that through the connections made during the KTP, continous links between academia and industry will be forced.

At the same time, JMA's practice also benefited from the academic understanding of BIM related issues effectively and allowing them enter the BIM arena with a more mature and intensive level of knowledge. Furthermore, via KTP, new insights have been gained and new knowledge created.

Overall, the KTP served for the government policy without regarding the sector. In other words, construction sector is seen as a traditional and culture driven sector. However, it is also required to be knowledge and technology driven in the 21st century to be able to compete in the global market, meet the sustainability requirements and complete construction projects on or under time and budgets. Thus, BIM, as a knowlegde and technolgy based working methodology for whole building lifecycle, can be embeded into the construction companies, majority of which are SMEs,via KTP projects while keeping the univesities teaching and research agenda up to date and coinciding with the industry.

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