TURNING KNOWLEDGE INTO ACTION: SKILLS DEVELOPMENT AND CHALLENGES IN BIM PROJECTS

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Building Information Modelling (BIM) is a recent technology introduced in construction industry to increase productivity in construction projects. However, construction industry is slow in adopting new technologies due to skills challenges within project teams. Therefore the main objective of this paper is to explore the required skills to complete BIM related activities and to identify the approach taken in the industry to acquire these skills. Semi structured interviews were conducted with professionals working in BIM enabled construction projects to understand current skills challenges faced by project teams and to attain knowledge about the skills required to effectively complete BIM construction projects. Analysis of the results includes the identification of current skills challenges and the key issues in adopting skills for the improvement of project performance and productivity. The paper presents evidence that skills during a technology change such as BIM can be gained through four main stages such as core knowledge development, understanding practice, using knowledge in practice and continuous practice. However the evidence also suggests that turning knowledge into action is not a linear process especially in the early days of a technological change.

Keywords: Building Information Modelling (BIM), Construction Industry, Productivity, Skills, Technology.

INTRODUCTION

The Construction industry lags behind other industries in terms of efficiency and productivity due to its fragmented nature and its resistance to adopt new technologies introduced within the construction projects (Murphy, 2014). New technologies within the construction industry are introduced to alter and create quicker ways to deliver goods and services (Corney, 1997), high performance work practices (Bresnahan et al, 2002), skills development (Hansushek and Woessmann, 2008) and high level of productivity (UKCES, 2015). In addition it has also improved the specialised and operative activities involved within the construction industry (Bosworth, 2013). Moreover recent studies in construction industry highlight the skills challenges as a major barrier in achieving high level of productivity (Blooms et al, 2004; Grant et al, 2013; UKCES, 2015). Focusing on resolving skills related issues provide an opportunity to improve and avoid these difficulties faced in construction industry. According to the construction skills report (2004) employers' skills requirements need to be taken into consideration to introduce complete change and to enhance the efficiency of the construction projects. Building Information Modelling (BIM) which

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is one of the recent technologies is introduced within the construction industry to improve construction projects. However, BIM is not utilised to its potential due to skills related challenges faced in the construction industry. The research discussed in this paper studies these skills issues and identifies a way forward for the UK construction industry.

LITERATURE REVIEW

BIM in construction industry

Construction industry has been continuously changing with the introduction of new technologies. Moreover, the introduction of new technologies have led the production process to take a 'techno-economic view' (Cardoso, 2000) which promotes the professionals to adopt higher and broader varieties of duties and skills (Lundval, 2004). According to Yisa et al (1996) this change cannot be avoided either by an individuals or organisation involved in construction industry. Among the technology used within the construction industry Building Information Modelling (BIM) is a recent technological development seeking to integrate processes throughout the entire project lifecycle (Aouad and Arayici, 2010). The importance of BIM adaptation is highlighted in several studies (Suermann and Issa, 2009; Azhar, 2011; Cabinet Office, 2011). Furthermore, recent BIM projects in the UK have established the immediate benefits such as clash detection, cost reduction, clear scheduling and swifter fabrication using data from BIM models (Nisbet and Dinesen, 2010). BIM can be defined as "digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition" (CPIC, 2011). However, Davidson et al (2009) describes BIM as 'a disruptive technology' as it will transform many aspects of the construction industry. On the other hand National BIM report (2012) has mentioned BIM as "a collaborative process of design, procurement and building operations". Furthermore, Kymmell (2008) claimed BIM as ''an intelligence that mitigates from 2D to 3D and creating intelligent and multi-dimensional building models''. There are many ways of looking at BIM; however, this study has viewed BIM as a way of working which is a combination of building information modelling and information management in a team environment, where all team members work to the same standards. In BIM, skills related issues are more centred on technology and people therefore this particular view is adopted for this study.

UK government has mandated to use BIM in public sector projects since 2016 (Cabinet Office, 2011) therefore construction companies have slowly started to adopt BIM in their construction projects. However, not having the necessary skills to use BIM within the construction project teams has been identified as a major barrier in the effective use of BIM (Cheng, 2006; Esposto, 2008; Hartmann & Fischer, 2008; Gu & London, 2010; Wong et al, 2011). Eadie et al (2013) from their study established that even though there are other reasons for not using BIM, lack of expertise within the project team is the most common reason for not using BIM within the construction projects. Moreover BCIS (2011), CIOB (2013) and NBS (2014) reports indicate the urgent needs for appropriate skills in BIM construction projects. In similar the study

by Giles et al (2004) argue that existing workforce skills needs to be changed to meet client's expectations during a technological change.

The term skills can be defined in different ways. Becker (1964) and HM Treasury (2006) define skills as the capabilities of doing a certain occupation or range of activities. Odusami (2002) states skills are abilities to perform the task better than the average including the ability to translate the knowledge into action. Moreover, skills are also looked from other point of views such as expertise (Wood, 1988), emotional reaction (Boyatzis et al, 2002) and dexterity and knowledge of the workforce (Mangham and Silver, 1986). In general, skills development encourages economic performance (OECD, 2000; O'mahoney and de Boer, 2002), innovation and flexibility (Leiponen, 2005). Moreover it helps to determine individual's employability to productivity (Leuven, 2005; Leitch review, 2006) and business profitability (Bosworth, 2013). The study conducted by Autor et al (1998) discussed about upgrading skills during the implementation of IT from 1970s to 1990s and identified that the use of computers have increased throughout the years. Alshawi and Faraj (2002) discussed about the development of technology and effective implementation. Initially this study investigated about sharing project information with the IFC (Industry Foundation Class) and highlighted the difficulties faced in achieving successful implementation in construction industry. Hwang (2003) studied about the diffusion of information and changes in skills in the UK during 1980s and investigated how they have changed in later years. On the other hand some studies have identified technical skills, management skills, interpersonal skills, managerial skills and administrative skills as the primary skills to work with BIM (Kymmell, 2008;Gu and London,2010;Succar,2013). Moreover, recent studies have focused skills issues in relation to economic performance (CITB, 2015; UKCES, 2015).

Skills Challenges and Economic performance

The UK economy has been growing since 2013 and has increased 2.8% in 2014 (ONS, 2014). This has improved job opportunities and employment rate however the productivity is stagnant and has fallen further down since 2007 (ONS, 2015). Productivity is essential to be considered because it determines the competitiveness for the business and wages for people at work (UKCES, 2015). According to HM Treasury (1988) productivity is 'a fundamental yardstick of economic performance' and the UK government is not productive enough compared to the other countries due to not performing to the standards. The construction industry has been one of the main engines of UK economic growth during 2014 (CITB, 2015) nevertheless still UK's productivity gap is driven back due to skills challenges faced in the construction industry. The UK firms have reported that they are reluctant to invest in new technologies because of the issues in maintaining and upgrading skills that are required to complete a job.

People with skills in jobs play an important and sustainable part in the UK productivity growth. However skills related challenges are one of the major barriers for lower level of the productivity and they hold employees back from achieving targets (CITB, 2013). Therefore, currently there is a need for people who are capable, agile and able to respond to the challenges presented by the new technologies. This is also highlighted in Sami's (2008) study where he mentioned more attention is needed to reskill, multi-skill or upskill professionals in the construction industry to successfully achieve project targets. In this study skill challenges have been viewed

from skills gaps, skills shortages and latent skills shortages point of views in order to improve productivity. Skills gaps occur within the workplace where a firm has employees but they are not skilled enough to meet the organisation's objectives (Campbell et al., 2001). Whereas skills shortages happen when there is shortage of suitable skilled people in labour market to fill in the vacancies (Barnes and Hogarth, 2001). Campbell et al (2001) state that skills gap affect more employers compare to skills shortages. One of the reasons for skills gaps is employers feel they are not recruiting people with the right skills. In UK, skills gaps include the basic skills (literacy, numeracy and computer skills), intermediate skills, and leadership and management skills. In addition there is also evidence of generic skills gaps such as motivation and attitude to learn (Bloom et al., 2004). Conversely Crafts and O'Mahoney (2001) believe that skills shortage plays a significant role towards the level of productivity. Supporting this Bloom et al (2004) mentioned that skills shortages are clear within UK construction industry and at the same time whatever the perception on scale of shortage, there is a growing demand for skills. Apart from this, latent skills shortage is also an issue, which is a situation where establishment fall short of what might be considered good or best practice which might be the reflection of low skills or poor business performance, even though there is no report of recruited problem or skills gap (Hogarth,2001). Generally this occurs when the organisation starts to manage a project with existing skills without being aware of necessary skills. Chan and Cooper (2006) claim that this situation is more frequent in construction industry because construction practitioners often do not know what skills they need to produce positive project outcomes.

Looking at skills challenges from an economics perspective, it can be argued that UK construction industry needs to identify the skills they require to successfully deliver product and services with the aid of new technology. Although the literature states that skills challenges is a major barrier to achieve higher productivity there is no clear evidence of how these required skills are achieved within the construction projects during an implementation of new technologies. Endogenous growth theory states that technological changes are usually skilled based and there is a need to have necessary skills among the employees to improve the productivity, and to respond to competitive environment. In this theory human capital is considered as one of the primary drivers of growth and the view taken in this paper consider that skills improvement is a key factor of human capital that counts for economic growth. This views is been supported by Bloom et al (2004) where he claims even though new technologies are out there significant amount of knowledge and skills is not there to work with those new technologies. Therefore this study focus on identifying the current skills challenges in UK construction industry during the implementation of new technology and the way they are achieved within the construction projects to improve productivity.

METHODOLOGY

Philosophical worldviews have influence on practice although they are often implicit within the research (Slife and Williams, 1995). Critical realism is a philosophical perspective about reality and human knowledge (Bhaskar, 2008). This view accepts the existence of an intransitive domain of objective knowledge but also accepts that it can never be purely unmediated since access to this domain is always socially constructed and is always subject to change. Consequently key to a robust enquiry is to adopt a wide critical perspective on both ideas and practices (Cidik et al, 2013).

This is appropriate for this study because the perspective of critical realism considers the BIM technology as existing independent of people who interact with it and having influence in development of knowledge and skills which are socially constructed.

The purpose of this investigation is to explore how project teams work with a new technology and to understand how they achieve the skills needed to complete the tasks in BIM environment. This research involves with detailed description of the situation, observed behaviour and interaction with people to ask about their experiences and beliefs. Therefore, qualitative research is adopted as a method best suited to explore the new area. Qualitative research is ‘‘Multi-method in focus, involving an interpretive, naturalistic approach to its subject matter’’ (Denzin and Lincoln, 1994). In other words it is a method of exploring and understanding the meaning where individuals or groups ascribe to a social or human problem (Creswell, 2008). The purpose of this qualitative method study is to understand how construction project team members gain their knowledge and skills during technology change within the construction industry. Data for the qualitative analysis was collected through semi structured interviews conducted with BIM experts working in the UK construction industry. There are many project participants involved in construction projects however this study has only focused on the BIM managers and BIM coordinators who closely work within BIM environment. BIM managers interviewed were managing and coordinating people who were involved in BIM processes. In addition they provide the appropriate guidance for the team members while decision making. At the same time BIM coordinators were involved in forming models and tools and to support the functions and to operate alongside with BIM technicians.

Semi structured Interviews

In this study, as the initial step professionals working with BIM across UK construction industry were interviewed to understand the significance of skills related issues in BIM construction projects and to understand how they achieve skills during the implementation of BIM in UK construction projects. The purpose of this interview is to collect interviewee opinion about the skills required to complete BIM related activities and its impact on the productivity. In addition this method is chosen to understand the in-depth experiences and to explore individual perception of professionals engaged with BIM construction projects. Most of the interviewees were chosen through university contacts and some were selected from LinkedIn professional groups where their experience with BIM technology were more than 5 years and had quick access to BIM related information compared to other project participants. Two pilot studies were conducted with the construction professionals working with BIM before conducting the interviews. This has helped to refine the questions with appropriate wordings and to confirm whether the questions seems sensible to the interviewees. In semi structured interviews conducted across the UK, open-ended questions were employed to get a wider view of the situation and interpretation was done along the way. The data collected through semi structured interviews explains how the skills are achieved through out their experience working with BIM.

DATA ANALYSIS AND DISCUSSION

The data collected from the semi structured interviews with BIM experts were divided in four different stages such as core knowledge development, understanding practice, using knowledge in practice and continuous practice. It is concluded that after the continuous practice stage, employees maintained a high level of productivity.

Core knowledge development

BIM in construction industry is fairly a new concept and the construction project team members consider this as a new way of working. Most expressed that initially they were reluctant to use BIM and the understanding fundamental aspects of BIM enabled them to consider the new technology. This involved in understanding what BIM is and some of the benefits associated with it. According to the interviewees they then started to use BIM in their construction projects due to clients' request and to utilise BIM benefits to achieve more profits. Many BIM advantages were highlighted during the interview such as putting the right process on place, generating models for facility management, watching the on-going maintenance, increasing the speed in creating schedules and drawings, enhancing the coordination, risk management, reducing reworks through managing the errors in early stage of the project. Majority of the interviewees acknowledged that BIM implementation in future UK construction projects is beneficial however they agreed current skill challenges need to be resolved to fully utilise BIM. The interviewees acknowledged that the fundamental knowledge about BIM was gained through various learning methods such as degree programs/ education, self-learning, basic software training, attending meeting, conference and workshops. During the discussion they also mentioned that knowledge about BIM was hard to achieve in the earlier days due to lack of case studies and on-going projects however it is agreed that now there are plenty of guidance, protocols and case studies that can be referred easily.

Understanding practice

This stage involved the professionals understanding the distinction between theoretical and practical knowledge related to BIM. After gaining the basic knowledge and information about BIM, professionals started to step into the next stage which is the general understanding about BIM in practice. In this stage professionals obtain the holistic knowledge about BIM which includes information on theoretical background of BIM, software used, people involved and the way BIM process is managed. During this stage professionals started to understand how BIM is being used by the project participants in construction projects. Interviewees mentioned that this is generally achieved through observing or communicating with BIM champions working in on-going BIM construction projects. At end of this stage it gave them an overall picture of how BIM is being practiced within the construction industry and they were also able to differentiate the knowledge in practice from theoretical knowledge they have learnt.

Using knowledge in practice

In this stage after understanding the overall picture participants started to use BIM in their practice. Interviewees stated that in this stage they had to face several skills gaps

such as detailing elements in BIM applications and using software , lack of understanding about family creation and detailed understanding, lack of knowledge about in putting the data into the objects and extracting it, process and standard gaps and lack of engineering. Moreover it has been realised that these gaps occur within internal workforce where professionals recruited are not deemed as a fully proficient. On the other hand some interviewees indicated that even though they think they have enough skills to work with BIM the project outcomes were not achieved to the required standards. This is due to latent skills shortage where skills gaps are unrecognised because project organisations have simply coped operationally without the necessary skills. This latent skills shortage is evident in some stakeholders such as sub-contractors, manufacturers and suppliers who are struggling to achieve project outcomes due to lack of involvement with BIM technology. In BIM projects latent skills shortages are derived from lack of defined project process, lack of understanding of role and responsibilities and frequent change of software to work with BIM. In addition this happens more often in BIM construction projects due lack of communications between the project team members. In other words the problems faced by the project team members are rarely discussed among them and in most of the situation doesn't not get reported to the top management. BIM professionals indicated that skills challenges are a major barrier in achieving positive project outcomes. This clearly demonstrates that skills gaps and latent skills shortages are significant constraints to performance. Interviewees believed that investment in skills could produce a radical shift in employees' perception of working which can lead to a higher level of productivity.

Interviewees also mentioned that they had made several mistakes due to lack of systematic approach, not fitting data into scheduling tool, lack of use of BIM sheets with the BIM execution plan, shifting to different software due to constant change of software, putting too many details and manual annotations in the BIM model and not having right understanding about BIM information. They believed that this is due to not having required skills and suggested that enhancing the necessary skills will help them to avoid these mistakes in other projects. Moreover they have identified certain skills such as level of understanding the overall process, understanding client's needs, awareness of disciplines, collaboration and communication with stakeholders, technological skills, coordination skills, engineering, commercial and management skills as the primary skills necessary to work with BIM.

Interviewees mentioned some of the constraints faced during working with BIM construction project were understanding the technology, lack of communication, lack of understanding the roles and responsibilities they fit in, different viewpoints and standards, lack of top management understanding, bringing everyone to the same page and providing training to different age groups . However they believed that improving the required skills could be useful to detect the conflicts in the early stage, understand the tools and the way software works, increase hands on practice with tools and software packages and encourage communications among the project team members. All the professionals interviewed strongly believe both formal (academia) and informal (industrial training) educations are essential to work efficiently with BIM. In this situation education provides the theoretical knowledge of BIM whereas training helps to understand BIM practice.

Continuous practice

In this final stage professionals acknowledged these identified skills are centred on three key areas which are BIM learning, BIM training and BIM practice. Challenges of using BIM in practice can only be gained by engaging in practice. This triggers the need to gain more understanding or training in specific areas. Interviewees claimed that with continuous practice they become a skilled personal with ability to deal with BIM issues in any project setting. However they also expressed that every project is unique and comes with its own BIM related challenges. Therefore they suggested more training, engaging with other BIM projects, following BIM courses, getting constant feedbacks about software from the newsletters, understanding the standards and setting out the project goals in the beginning of the project can be done to achieve better project outcomes. This stage could be claimed as the space where knowledge turns into action and required skills are achieved.

CONCLUSION

Skills challenges are one of the major barriers in achieving efficient project outcomes. At present, construction projects are introducing new technologies such as BIM to increase productivity. However this study has identified that skills gaps and latent skills shortages are major constraints in achieving better project outcomes in BIM construction projects. Therefore it is important to focus on upgrading skills during a technological change. This paper has identified understanding the overall process, understanding client's needs, awareness of disciplines, collaboration and communication with stakeholders, technological skills, coordination skills, engineering, commercial and management skills as primary skills to work with BIM. Moreover the study has concluded that these identified skills can be achieved through four main stages which are core knowledge development, understanding practice, using knowledge in practice and continuous practice. However the evidence also suggests that turning knowledge into action is not a linear process. BIM experts interviewed in this study suggest the knowledge development through these stages can be enhanced through more training, engaging with other BIM projects, following BIM courses, getting constant feedbacks about software from the newsletters, understanding the standards and setting out the project goals in the beginning of the project and communicating with BIM champions.

REFERENCES

Alshawi, M., and Faraj, I. (2002). "Integrated construction environments: technology and implementation." Construction Innovation, 2(1), 31-51.

Aouad, G & Arayici, Y 2010, Requirements Engineering for Computer Integrated Environments in Construction, Wiley-Blackwell, Oxford, UK

Autor, D.H., Katz, L.F., Krueger, A.B., 1998. Computing inequality: have computers changed the labor market? Quarterly Journal of Economics 113, 1169 – 1213.

Azhar, S. (2011) 'Building Information Modeling (BIM): Trends, Benefits, Risks and Challenges for the AEC Industry', ASCE Journal of Leadership and Management in Engineering, 11 (3), 241-252.

Barnes.,S.A and Hogarth., T. (2012). Sector Skills Insights: Education. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303992/Sector_Skills_Insights_Education_evidence_report_57.pdf. Last accessed 30th of October 2015.

Bhaskar, R. (2008). A Realist Theory of Science, 3rd edn. London, Verso Books.

Becker,G.(1964), Human Capital, New York: NBER Columbia University Press.

Berman, E., Bound, J., Machin, S., 1998. Implications of skill-biased technological change: international evidence. Quarterly Journal of Economics 113, 1245 – 1279.

Bosworth.D.L. (2013). UK Skill Levels and International Competitiveness, 2013. UK Skills level and international competitiveness.

Boyatzis, R.E., Stubbs, L. and Taylor, S. (2002), "Learning cognitive and emotional intelligence competencies through graduate management education", Academy of Management Journal on Learning and Education, 1(2), pp. 150-62.

Bloom.,N, Conway.,N, Mole.,K, Möslein.,K and Neely., A (2004). Solving the skills gap. Available: http://wi1.uni-erlangen.de/sites/wi1.uni-erlangen.de/files/Solving_the_Skills_Gap1.pdf. Last accessed 30th of October 2015.

Bresnahan, T., Brynjolfsson, E., and Hitt, L. M.(2002) "Information Technology, Work Organization and the Demand for Skilled Labor: Firm-Level Evidence," Quarterly Journal of Economics ,117 (1), pp. 339-376.

Building Cost Informative Service (BCIS) (2011), ''RICS 2011 Building Information Modelling Survey Report''. London: The Royal institute of Chartered Surveyors.

Cabinet Office (2011), ''Policy Paper Government Construction Strategy, Documents, Government Construction Strategy: One year on and Action Plan Update'', London. Available at https://www.gov.uk/government/publications/government-construction-strategy. Last Accessed 12th July 2015.

Campbell, M. (2001). Skills in England 2001: The Research Report, Department for Education and Skills, UK, November

Chan, P., Cooper, R. and Tzortzopoulos, P. (2005) Organisational learning: conceptual challenges from a project perspective. Construction management and economics, 23, 747 – 756

Cheng, R. (2006) ''Questioning the Role of BIM'', Available from: Open Source Repository, Available at http://www.aecbytes.com/viewpoint/2006/issue_26.html Last Accessed 3rd July 2015.

Cidik, M, Boyd, D, and Thurairajah, N (2013) Managing the polarised perspectives in BIM Enabled Projects. ARCOM Annual Conference 2013, 2-4 September 2013, Reading, UK.

CITB. (2015). INDUSTRY INSIGHTS: Construction skills network blueprint for construction 2015-2019. Available: https://www.citb.co.uk/documents/research/csn%20reports%202015-2019/construction-skills-network-uk-2015-2019.pdf. Last accessed 30th of October 2015

Corney, M. (1997). 'Individual Lifelong Learning Accounts: Research Consortium III', Chichester: M.C. Consultancy (mimeo).

CPIC. (2011) ‘‘Building Information Modelling, Drawing is Dead- Long Live Modelling’’, Available at http://www.cpic.org.uk/en/bim/building-information-modelling.cfm Last Accessed: 26th July , 2015.

Crafts N., and O’Mahoney M., (2001) ‘A Perspective on UK Productivity Performance’, Fiscal Studies, vol 22, no. 3, Institute for Fiscal Studies.

Denzin and Lincoln.,Y.S (Eds.),‘‘Handbook of qualitative research’’ London: Sage., pp. 105-117.

Eadie, R., Odeyinka, H., Browne, M., McKeown, C., & Yohanis, M. (2013). An analysis of the drivers for adopting building information modelling. ITcon, 18, 338-352.

Edwin Leuven.,E , Bassanini, Andrea, Alison Booth, Giorgio Brunello, Maria de Paola, (2005). Workplace Training in Europe. IZA Discussion Paper No. 1640.

Esposto, A. (2008), “Skill: An Elusive and Ambiguous Concept in Labour Market Studies”, Australian Bulletin of Labour, 32(1), pp.100-124.

Giles, L and Campbell, M (2003) ‘‘The productivity and skills change’’, Industrial and commercial training, 35(3),pp. 99-103

Giles, L., Tamkin, P., Campbell, M. and Hillage, J. (2004), “Skills pay: the contribution of skills to business success”, Research Report No. 5, Sector Skills Development Agency (SSDA).

Grant, T. (2013). No labour shortage on the horizon, study says. The Globe and Mail. Retrieved from http://www.theglobeandmail.com/report-on-business/no-labour-shortage-onhorizon-study-says/article15324642/#dashboard/follows/. Last accessed on 23rd August 2015.

Gu.,N. and London., K. (2010) ‘‘Understanding and facilitating BIM adoption in the AEC industry’’. Automation in Construction. 19, pp. 988-999.

Hansushek.E.A and Woessmann. (2008). The Role of Cognitive Skills in Economics Development. Journal of Economic Literature. 46 (3), 607-668.

Hartmann, T. and Fischer., M. (2007) “Applications of BIM and Hurdles for Widespread Adoption of BIM.” The 2007 AISC-ACCL eConstruction Roundtable Event Report, New Orleans, LA.

HM Treasury. (2006). Prosperity for all in the global economy - world class skills. Leitch Review of Skills .HMSO.

Hwang.G, (2003),"Information and communication technologies and changes in skills", International Journal of Manpower, Vol. 24 Iss 1 pp. 60 – 82.

Kymmell.,W. (2008) “Building Information Modelling : Planning and Managing Construction Projects with 4D CAD and Simulations”, United States :McGraw – Hill Construction Series.

Leitch Review (2006), HM Treasury, The Stationery Office, London.

Lorenz, E., Wilkinson, F. and Michie, J., 2004. HRM Complementarities and Innovative Performance in French and British Industry’, forthcoming in , J. Christensen and B.-A. Lundvall (eds.) Product Innovation, Interactive Learning and Economic Performance, Elsevier Ltd.

Leiponen,A.2005 ‘‘Managing knowledge for Innovation: The case of business and business services’’, Journal of Product Innovation Mnagement;Vol,23,No.3,pp-238-258.

Leuven.,E , Andrea.,B, Booth.,A, Giorgio.,A Brunello.G, Paola, A.,M(2005). Workplace Training in Europe. IZA Discussion Paper No. 1640.

Mangham., I and Silver., M (1986) Management Training: Context and Practice, Bath: Economic and Social Research Council.

Murphy, S., Spillane, J., Hendron, C., and Bruen, J. (2014). "NEC Contracting: Evaluation of the Inclusion of Dispute Review Boards in lieu of Adjudication in the Construction Industry in the United Kingdom." Journal of Legal Affairs and Dispute Resolution in Engineering and Construction,

National Building Specification (NBS) (2014), ‘‘National BIM Report 2014’’, RIBA enterprises Ltd, London.

Nisbet, N. and B. Dinesen (2010), Construction the Business Case: Building Information Modelling. BuildingSmart: International Alliance for Interoperability: London.

Odusami, K.T, (2002). Perception of Professionals Concerning Important Skills of Effective Project Leader, Journal of Management in Engineering, 18 (2), pp 61–67.

OECD (2000a), A New Economy? The changing role of innovation and information technology in growth, Paris.

Office of National statistic (ONS)(2014). Gross Domestic Product Preliminary Estimate, Q4 2014

Office of National statistic (ONS) (2014) ‘Productivity measures’.

O'Mahoney., M., and de Boer., W. (2002), ‘‘Britain's relative productivity performance: Has anything changed?’’ National Institute Economic Review, 179, pp. 38-43.

Ruiz.Y. (2004). Skills shortages in skilled construction and metal trade occupations. Labour Trends., pp.104.

Sami. (2008). 2020 Vision – The Future of UK Constuction. Available: http://www.cskills.org/uploads/2020visionscenariosforconstructionskills_tcm17-11077.pdf. Last accessed 30th October 2015.

Slife, B. D., & Williams, R. N. (1995). What's behind the research: Discovering hidden assumptions in the behavioral sciences. London: Sage.

Suermann., P.C. and Issa,R.R.A. (2009) ‘‘Evaluating the Impact of building Information Modelling (BIM) on Construction’’. Available at http://www.engr.psu.edu/convr/proceedings/papers/22_Suermann_submission_47.pdf . Last accessed 16th August 2015.

The Chartered Institute of Building (CIOB) (2013) ‘‘A report exploring Skills in the UK Construction Industry’’. CIOB: Berkshire.

UK Commission for employment and Skills (UKCES). (2015). Annual reports and accounts 2014/2015.Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/441289/UKCES_2014-15_Annual_Report.pdf. Last accessed 29th October 2015.

Wong, K. A., Wong, K. F., & Nadeem, A. (2011). “Building information modeling for tertiary construction education in Hong Kong.” J. of Information Technology in Construction, 16, 467-476.

Wood, D.K. (2009). “Research Assessment Adviser.” http://www.research-assessmentadviser.com/researchterminology.html , Last accessed on 12th May 2015.

Yisa.B.S, Ndekugri and Ambrose.B. (1996). A Review of the change in the UK construction Industry. European Journal of Marketing. 30 (3), 47-64.