

# INVESTIGATING A SUITABLE LEARNING ENVIRONMENT TO ADVANCE SUSTAINABLE PRACTICES AMONG MICRO CONSTRUCTION ENTERPRISES

Michael P Gleeson<sup>1</sup> and Craig S Thomson<sup>2</sup>

*School of Engineering and Built Environment, Glasgow Caledonian University, G4 0BA, UK*

Sustainability in the construction industry is increasingly at the forefront of current debate and government policy. The majority of sustainable strategies and research has focused on large contracting organisations with little attention given to Micro Construction Enterprises (McE's). With McE's comprising of 98% of all UK construction firms they clearly contribute significantly to the delivery of sustainability. There is little understanding of the unique challenges McE's face in learning and knowledge acquisition to advance sustainable practices. McE's are a diverse group of professional practices, specialist trades and general builders and it is doubtful they are well equipped to support the learning culture necessary to appreciate the current myriad of sustainability issues. This research explores the requirements for a suitable learning environment for McE's to advance sustainable practices. Through semi-structured interviews with eight owner/associates of different types of McE's in Glasgow, the research explored their preferences for learning in order to establish the basis for a suitable learning environment. Formal methods of learning like seminars and CPD events entail prohibitive cost and resource barriers, but analysis suggested that these constraints could be appeased by facilitating voluntary informal learning pathways in order to progress the agenda. Since the majority of the study participants were members of some trade or professional association it is recommended that these bodies are best placed to deliver contextually relevant resources in a suitable narrative for McE's. The paper attempts to differentiate between formal and informal learning styles to promote sustainable practices among McE's.

Keywords: knowledge, learning, micro construction enterprise, practice, sustainable construction

## INTRODUCTION

Irrespective of personal views on Climate Change a large body of corroborated evidence suggests that the industrialised nations of the world are having an adverse effect on the earth's ecology and climate systems, to devastating effect (IPCC, 2007). The UK government's goal is to achieve an 80% reduction in carbon emissions by 2050 (RAENG, 2010) in line with a path for sustainable development which seeks to

---

<sup>1</sup> mgleeson10@yahoo.co.uk

<sup>2</sup> craig.thomson@gcu.ac.uk

balance social and economic progress within environmental limits. To counteract the construction industry's impact on the environment, various UK government strategies have been drawn up to drive the sustainable construction agenda (BIS, 2010a).

This represents an ever changing landscape within which micro-construction enterprises require to learn and evolve their practices. The European Commission, define micro enterprises by a headcount of between 0-9 employees, with an annual turnover or balance sheet of 2 million Euros or less (EC, 2009). Although certain studies distinguish between micro, small and medium enterprises the majority of studies use the Small and Medium Enterprise (SME) classification only. Previous research has shown that micro construction enterprises (McE's) are a distinct group from SME and worthy of special attention (Sommerville and McCarney, 2003). Recent statistics illustrate that 98% of all construction industry firms in the UK comprise of McE's (BIS, 2010b), with a significant 85% of these firms being sole traders or self employed individuals. With McE's representing 62% of employment within the UK construction economy (BIS, 2010b), it is fair to propose the collective 'ecological footprint' of small firm's warrants serious attention (Revell, 2007). Various commentators agree that McE's are often overlooked in big policy movements with low levels of engagement in the environmental agenda (Davey *et al.* 2001). Yet, with the proliferation of sub-contracting in recent times perhaps the most important group in a construction project is the sub-contractor, often completing up to 90% of the project value (Sommerville and Thomas, 2009). The research aims to explore a suitable learning environment for McE's to advance sustainable construction practices to promote the triple bottom line principles of sustainability.

## **CHALLENGING CONTEXT: LEARNING AND DEVELOPING PRACTICE WITHIN MCE'S FOR SUSTAINABILITY**

The adoption of an integrated vision between all the project stakeholders is essential in tackling sustainability (Desai, 2009). Various strategic reviews of the UK construction industry in the last 20 years lament the dichotomy between design and construction, with the problem surrounding the structure of the industry being continually discussed and revisited (Walthamstow, 2009). Part of this fragmentation is the abundant use of sub-contracting as the preferred procurement route within the UK construction sector resulting in a loss of in-house technical expertise. Walthamstow (2009) maintains that subcontracting represents horizontal interfaces which place further barriers against the free flow of information and innovation. Therefore any proposed learning environment for McE's must take cognizance of these constraints which impede the integrated thinking and working that is necessary for sustainable practices. In addition, it is important to recognise that McE's act in a diverse array of roles, as professional consultants, specialist or general main contractors, sub-contractors and as individual sole traders. Large contracting organisations are constantly lauded as industry leaders yet they do not undertake the majority of renovation and maintenance of the UK's private housing stock. This is predominately carried out by 'Small and McE's'. This is important since it is the UK government's goal to achieve an 80% reduction in carbon emissions by 2050, while it is estimated that up to 80% of buildings occupied in the year 2050 have already been built (RAENG, 2010). Hence, the example of retro-fitting highlights the case to better understand what constitutes a workable learning environment for sustainable construction and design among McE's. Time and financial constraints usually have an adverse impact on McE's ability to engage in learning and the development of skills needed for sustainability. It seems that the apparent failure of the agenda to date could

be attributable in part to a lack of serious engagement and targeted consultation with McE's. Through a feasible learning path and collaborative measures McE's could regain some of these technical expertise required for sustainable learning and practice.

### **Collaboration - building alliances for learning (challenges & remedies)**

Wheeler (2004) aptly concludes, no singular solution is enough by itself rather a mutually reinforced set of actions is necessary at all levels. Some commentators propose that the collective problem of un-sustainability necessitates both top-down directives and bottom-up innovations and initiatives (Rees, 2009). In others words, it becomes imperative to inspire an integrated vision between project participants and stakeholders to build sustainable communities (Desai, 2010). Sommerville and McCarney (2003) view it as misdirected policy to assume that change will trickle down from large enterprises and ultimately to micro firms, the evidence of which is the relatively meagre progress made to date in sustainable practices. This lack of interaction between macro and micro level learning appears to be a crucial problem and is perhaps a reflection of the industries ingrained traditional top-down management mentality. Through promoting clusters of McE's with external consultancies and trade association's such alliances and new ways of thinking required for sustainable development can be cultivated (Will, 2007). Such collaborative working can serve to mitigate uncertainty and provide a confluence of specialists to address the problem of un-sustainability. Perhaps the radical thinking and appreciation for sustainability among McE's can forge meaningful collaborations for sustainable practices, where profit is not always the bottom line.

### **Policy and legislation**

Revell's (2007) study found that most SME's considered the best approach was to implement more rigorous legislation, in a similar way to how Health and Safety has been tackled. Regulation could create a level playing field regarding learning for environmental obligations for SME's in spite of the unpopular bureaucracy it entails (Holland and Gibbon, 1997). The array of current policy needs to become ratified in a practical approach to help cultivate a more structured learning environment for McE's. A similar study among house builders highlighted legislation as a key driver to cultivate a learning setting for McE's (Thorpe *et al.* 2008). With mixed views regarding legislator's ability to steer a sustainable course, consultation and meaningful engagement may play a key role in informing the most suitable learning methods for McE's. While balanced legislation and robust policy have their place it is important to define McE's position and galvanise their commitment so that they can be rallied towards sustainable concerns in the most efficient and effective manner.

### **Formal learning**

Murray (2009) advocates the personal approach to sustainable development by securing a level of personal engagement from the learner which empowers the individual to recognise the opportunities and act upon them with confidence and competence. Rees (2009) also hints at curriculum reform, proposing a need to instil creativity in students to shape this new dynamic built environment. Traditionally, education was highly discipline specific, making teaching an appreciation of sustainability more challenging due to a lack of disciplinary integration (Brncich *et al.* 2011). As Wheeler (2004) underlines the problem of compartmentalization and disjointed style of old-fashioned approaches are an impediment to a holistic outlook required for sustainability. Several professional bodies are recognising the need to incorporate sustainable teaching and are driving this forward, albeit confined to their

respective disciplines (Murray and Murray, 2007). This suggests a challenging cultural change is required with some suggesting a need to de-link some of the accreditation of courses by professional bodies (Brncich *et al.* 2011). As a compliment to core subjects, teaching in formal academic settings must impart the wide expanse of holistic knowledge needed to address the multifaceted reality surrounding sustainability in the construction sector. Such a formal learning strategy with an increased awareness of subsidiary subjects could equip new graduates with an awareness of the inter-connectivity of all knowledge and openness for collaborative working. Professional bodies like the CIOB, RICS, and the RIBA are highly influential in forming educational structures for their respective programmes and should take the lead in supporting learning for sustainability among McE's. Desai's (2010) perceives this setting at a personal level where teaching is imbued by a sense of how, individually, we can positively impact on the sustainable agenda.

### **Informal learning - Craft skills and professional disciplines**

Davey's *et al.* (2004) action learning study found that SME's are capable of being leaders of government initiatives to drive the industry, not simply the recipients. However, with 75% of McE's owners having not attended any sort of training programmes the lack of organisational learning was found to be a significant contributor to business failure (Sommerville and Thomas, 2009). To help rectify this, Holland and Gibbon (1997) advocate a consciousness-raising exercise, with a realisation of the impacts McE's place on the environment through trade associations, local authorities and business clubs. From a practical outlook the industry must develop enough trade's people and professionals with the necessary skills and competencies needed for sustainable practices. It is both vital for business durability and tackling the diverse issues which encompass sustainability.

Research indicates that education surrounding the sustainable agenda in construction was skewed in the main towards technology based solutions (Murray, 2009). Yet, an overemphasis on technology does not provide a truly coherent vision of sustainable living in the world (Desai, 2010). With the advent of technology driven sustainable practices this situation may become exacerbated and warrants further examination in practice. Informal learning styles may be more suitable for McE's with trade and craft backgrounds simply due to their inherent practical characteristics. This may suggest that there are differing learning needs and styles between professional consultancy practices, builders and craftsmen.

### **Influences of trade and professional bodies**

Trade and professional bodies were seen as providing relevant and contextual based knowledge and awareness about sustainable practices for small firm needs (Coetzer and Perry, 2008). Concerns relating to risk and finance could be abated through an educational process, one driven by trade bodies who could converse in a common language with their cohorts (Thorpe *et al.* 2008). Hence, it is essential to understand the factors which influence the experience of reality for McE's. Trade and professional associations could play an important role in supporting learning and the acquisition of relevant knowledge for McE's to advance sustainable practices. These bodies can support McE's to overcome resource limitations and through cooperation act as knowledge hub in tackling the agenda.

The review suggests that a suitable environment is required for McE's to learn in order to allow them to emerge as a significant force for change within the industry. It is suggested that to be successful this environment needs to draw on formal and informal

learning styles and engage with a range of education providers whilst promoting a holistic approach to sustainability driving process improvements within the industry.

## RESEARCH METHODS

The phenomenological paradigm was adopted as the most suitable framework to examine a variety of McE's and their relationship with learning for sustainability in the construction context. Sustainability elicits a diverse range of views depending on the level of knowledge, values and attitudes people hold towards the subject area and this paradigm ensures the research engages with practice.

Data collection: The EC terms enterprises as split between micro, small and medium as indicated on Table 1. This definition of McE's was utilised to identify appropriate participants to partake in the research project.

*Table 1: Micro Construction Enterprises - European Commission (Source: EC, 2009, p.3)*

Enterprise category	Ceilings		
	Staff Headcount	Turnover	Balance sheet total
medium-sized	< 250	≤ €50 million	≤ €43 million
small	< 50	≤ €10 million	≤ €10 million
micro	< 10	≤ € 2 million	≤ € 2 million

Key themes emerging were explored with eight owner/ associates of McE's during in-depth interviews. Given that the research concerns the exploration of opinions, feeling and perceptions of practitioner, these themes were considered in a loose/ flexible way to avoid enforcing an agenda and to allow the responses to be framed from their own viewpoint. The sampling frame consisted of interviews with eight owner/managers/directors of McE's within the Greater Glasgow area, to examine their learning needs and styles for sustainability as outlined in Table 2. By limiting the geographical scope it allowed the richness of the local environment and support structures to be considered in relation to the different McE's. It is hoped that the design parameters of the inquiry would protect against overstating any findings while the study is very much viewed as a pilot stage and platform for further research.

*Table 2: Research participants - Micro Construction Enterprises*

Professional Consultancy Practices Nr:1,2,3	General Building and Specialist Contractors 4,5,6	Individual / Sole traders 7,8
1: Director, Structural engineering consultancy (1 employee)	4: Director, Construction and Refurbishment Contractor (8 employees)	7: Architectural technician (Sole trader)
2: Architectural practice (partnership)	5: Director, Specialist Joinery Contractor (9 employees)	8: Specialist Renovation Contractor (Sole trader)
3: Architectural practice (partnership)	6: Operations Manager, Building Contractor (2 employees)	

A cross section of these firms provided an opportunity to examine the 'individual/sole traders' as a distinct group within the sampling frame of McE's. Interview participants

were provided through personal contacts who in turn suggested other likely participants from the McE’s grouping, with the additional use of online directories. Each interview lasted an hour on average and were recorded and transcribed in close proximity to when the interview was conducted (to facilitate ease of understanding and clarity). A limitation is reflected by only one interview being conducted for each McE category but this reflects the pilot stage of this research.

Data analysis: To aid the interview analysis a bespoke/hybrid coding method was adopted based on open coding techniques. This allowed the researcher to filter the coding process of the transcripts across paragraphs rather than on a line by line basis. The emerging findings were then organised under existing themes present in the literature review or new topic areas with a view to identifying the varying learning styles among the McE's participants within the study. The paper attempts to differentiate between formal and informal learning styles to advance sustainable practices among McE's.

## RESEARCH ANALYSIS AND FINDINGS

The study highlighted the importance of understanding that several auxiliary challenges exist to impede the learning process and ultimately its implementation in the context of MCE's and these are presented in Table 3. The discussion focuses around current status and future requirements for the two key learning environments surrounding sustainability in McE's- formal and informal.

Table 3: Challenges to learning for sustainability among McE's

CHALLENGES	
Lack of consensus on the definition and distinction of sustainability terminology	Too much information - a need to filter information and knowledge(relevant and contextualised) for McE's
Formal learning entailing prohibitive costs, while McE's operate with scarce resources	Misconceptions about sustainability - "it always costs more"
Greenwash - a need to curb the cynical/insincere use 'sustainability'; creates unnecessary market confusion	Attitudes - Narrow-minded, entrenched attitudes need to be explored through the learning process
A business case for sustainability not perceived as a feasible outcome in practice for McE's	Policy and legislation - Many conflicting government strategies and misdirected legislation
Bureaucracy and regulations - fallacy to believe the agenda can only be progressed through policy alone	Lack of Client engagement - education in building usage; motivate both client and contractor to learn
Assuming the agenda can only be advanced through large Contracting and Multi-disciplinary Consultancy firms (consumes support and learning resources)	Over-specialisation of knowledge sometimes hinders a broad appreciation of sustainability (curriculum reform - in craft/ vocational based training and academia)
Risks with new materials/technology. Perceived risk in using new unfamiliar/unproven materials	

### Formal learning

#### *Influences of trade and professional bodies*

Most of the McE’s interviewed were members of a trade or professional association, except for the two sole traders interviewed. For the majority of McE’s participants their influence was somewhat limited in orchestrating a formal learning setting perhaps due to the current voluntary nature of these practices. However, given a strong awareness of what these associations had to offer they may be ideally suited to delivering resources in a common language which is contextually relevant for McE’s.

Two of the architects interviewed worked as part time lecturers which provided opportunities to access more formal sustainability information and increase knowledge. When working as sub-contractors on large projects with more demanding clients, learning and knowledge for sustainability is enforced in a more regimented manner. One specialist joinery contractor felt that *"knowledge and learning for sustainability is mostly taken from a peer"*. However, many McE's also act as main contractors or design consultants and must instigate their own independent learning. The following sentiments of one contractor give some indication as to why formal academic routes for learning are sometimes not suitable: *"to achieve the knowledge most McE's will not have the finances to educate themselves and need some government or European backed funding"*. Although it has been found that McE's have negative perceptions about sustainable practices being forced on firms. One Architect interviewed felt that McE's were at a disadvantage for learning; *"there is support there, but it's easier for bigger practices to absorb cost, as training and conferences cost a fortune to attend"*. There seemed to be a feeling among all respondents that current formal modes of learning are difficult to access, cost too much and consumes time that is too valuable to lose.

He suggested a formal consensus on best practice, knowledge based solutions for sustainable retro-fitting and renovations were needed. For micro construction enterprises their suppliers and manufacturers play an important part in filtering information and making distinctions which can advance sustainable practices. One contractor suggested; *"they need to filter the good practical research with feedback and engagement from McE's"*. This could in part be conveyed through formal academic learning in addition to product manufacturers - *"when you are pricing a job you know exactly what you have to use, the architect knows, the engineer knows and the builder knows it's one or two materials and it's well known, available from one supplier"*. It was widely viewed among interviewee's that sensible regulations were integral to fostering learning and knowledge for sustainable building practices. One joinery contractor stated; *"McE's make up 97% of the industry, if these guys aren't been forced into increasing their competency and increasing their awareness they never will"*. Thus, regulations seem to be a necessary method in forming minimum standards for sustainability which requires training and this would work much better if cooperation and mutual consent was sought from McE's.

There was agreement among most interviewee's that attitudes could play an important part. A specialist joinery contractor thought that attitudes among McE's could be positively engaged in a similar manner to Health and Safety; *"like H&S, if we could change the attitude to sustainability by government saying every guy on site must have an awareness of what sustainability is and having set parameters for benchmarking to measure improvements"*. Likewise, another consultant architect proposed to overcome a poverty of aspiration; *"the biggest challenge is turning people away from habits of a lifetime and getting across to people what's in it for them"*. This alludes to marketing a strong narrative which creates a tangible vision for McE's to learn and instil personal responsibility. These McE's perceptions illustrate the prominence of attitudes on the sustainability agenda. Given the complex issue surrounding the agenda 'attitudes' may have more influence than regulations. Through probing and the exploration of attitudes within a learning setting McE's could be challenged to deliberate and reflect over their attitudes and beliefs in a positive way. For some contractors learning about sustainability was relatively easy but a wide gap existed in terms of implementing it in practice. Hence, learning initiatives for McE's must

ensure that the actual knowledge gained can be applied in construction practice, although a difficulty exists due to its often over-specialised nature. Indeed recent calls have emerged for changes to formal education curriculums within construction faculties to give student a broader appreciation and knowledge of other disciplines (Brncich *et al.* 2011; Rees, 2009).

Just one contractor identified the potential of supporting learning and developing knowledge around the context of retro-fitting, but it is clear from past studies that energy use in existing building stock must be targeted for reduction. For certain renovation works, due to the limited scope of suitable materials, knowledge for retro-fitting might be more easily tackled in terms of learning and practical applications for McE's. For all the McE's who participated in this study accessing existing support for formal learning, like CPD courses, was far too costly and often not easily accessible due to time and distance constraints. Collaboration between the many trade and professional bodies could potentially help to absorb some of the costs for their members through subsidies of events and learning materials.

### **Informal learning among McE's**

It's perhaps not surprising informal learning seemed to be favoured among McE's, resource constraints and work pressures made the suitability of this mode of learning attractive. Informal learning styles were sometimes influenced by professional bodies or by testing out practices in the field. As one consultant architect advocated; *"a lot of learning is practical application, reading literature, talking to suppliers, manufacturers and becoming knowledgeable about the product"*. In some cases professional and trade associations can promote informal learning and a knowledge environment for McE's. At a basic level this involved being kept updated about changes in regulation and sustainable building technologies. This was also achieved through e-newsletters and association websites and was one of the *"free ways to disseminate information"*. The internet, with its broad accessibility, was seen as a very useful tool for accessing information and helping to alleviate time and cost barriers associated with more formal learning methods. This sentiment was highlighted by a self-employed renovation contractor; *"If I get stuck for something I'll just go on the internet and try to research it, and I can do that after my work"*. To keep abreast with developments and increase their knowledge of sustainability some of the builders utilised industry websites, internet forums and even the video sharing website You Tube. A building contractor felt this was a progressive approach; *"the CIOB are very forward thinking trying to do different initiatives like a lot of forums and CPD events"*. Forums could offer a unique platform for challenging ideas, building consensus and providing McE's an increased awareness of the bigger picture.

In addition, sole trader seemed most optimistic about the benefits of You Tube; *"for some aspects of carpentry work on YouTube, you actually see a guy showing you how to do it from start to finish"*. The merits of such a learning tool may be specifically fitting for sole traders since they face the most pressing restraints in terms of time, human resources and finances. A more formalised approach to accessing educational materials via the internet offers the opportunity to reach McE's in rural areas aiding the wider promotion of sustainable practices. Such a mechanism informed by research, trade and professional bodies could ensure the credibility of information in the learning process could be validated for McE's. If the efficiency and effectiveness of learning can be improved among McE's the resultant knowledge acquired could be more readily translated into meaningful sustainable actions. Considering the advances



of online learning in recent years a similar thoroughness should be adopted and remodelled in a context and language appropriate McE's. A video sharing community could have wider appeal to McE's as a platform for the promotion of practical ideas and solutions relative to their work methods. Yet, one unique sustainable project showed that through voluntary labour and the testing of ideas on demonstration style projects provided a business case resulting in several funding bodies supporting their endeavours and the participants learning on the job.

Three of the contractors interviewed were members of some trade association. Perhaps not surprisingly, two of the sole traders, a renovation contractor and architectural technician, were not members of any associations. This possibly suggests some dissimilarity in terms of their varying ability to access available support compared to other McE's. Delivery of informal learning through the internet appeared to be suited to all McE's, and especially sole traders. Informal learning through associations seemed to be more prominent in professional practices among McE's. Learning specific to sustainability must provide a broad appreciation of the issues which is lacking via the over-specialisation of knowledge. This appreciation is fundamental to purposeful action for sustainable practices.

## **CONCLUSIONS/RECOMMENDATIONS**

This research revealed that consultancy practices and professionally managed contactors appear more inclined towards formal modes of learning than the sole trader (e.g. joiners and architectural technician). However, due to resource limitations both increasingly resort to informal methods of learning. Yet, the informal learning environment relies on the array of disparate bodies involved in compiling knowledge for sustainability which clearly lacks the joined up thinking necessary. The interviews revealed that such an environment provided a fragmentation of knowledge creating more confusion. McE's require knowledge to be emitted in a clear, plainly written manner with illustrative pictures for targeted audiences like tradesmen working on building sites with a focus to making their work easier.

The use of regulations to drive sustainability and stimulate a learning culture was viewed by most interviewees with a negative perception due to additional bureaucracy and cost, and therefore needs to be considered carefully when proposing any new strategy. Evidence suggests that an agenda that is forced on McE's will not foster a learning culture, although lessons can be taken from the health and safety agenda. However, when abstract global ideas are contextualised to the micro construction level, a business case can be created for sustainability and therefore a perceived need to learn might be more clearly fostered. The research highlighted that sustainability needed to be viewed as a broader more holistic concept than just green products and that changing attitudes is pivotal to cultivating a learning culture. Undoubtedly, genuine consultation should result in McE's being at the forefront of developing practical ways for knowledge to be devised and implemented given their significance within the industry. However, it is vital McE's get more financial support to create a suitable learning environment which is both formal and informal or increased support provided freely by way of seminars, CPD events or through the internet. This paper was preliminary in nature providing impetus for more in-depth research in the area of learning and knowledge to advance sustainable practices among McE's.

## REFERENCES

- Brncich, A, Shane, J S, Strong, K C & Passe, U (2011) Using Integrated Student Teams to Advance Education in Sustainable Design and Construction. "International Journal of Construction Education and Research", **7**(1), 22-40.
- Coetzer, A and Perry, M (2008) Factors influencing employee learning in small businesses. "Education and Training", **50**(8/9), 648-660.
- Davey, C L, Lowe, D and Duff, R (2001) Generating opportunities for SMEs to develop partnerships and improve performance. "BR&I", **28**(3), 1-13.
- Davey, C L, Powell, J A, Cooper, I & Powell, J E (2004) Innovation, construction SMEs and action learning. "ECAM", **11**(4), 230-237.
- Department of Business Innovation and Skills (BIS) (2010a) "Low Carbon Construction-Innovation and Growth Team, Emerging Findings." Spring 2010. Department for Business, Innovation and Skills. Crown Copyright.
- Department for Business Innovation and Skills (BIS) (2010b) "Small and Medium-sized Enterprise (SME) Statistics for the UK and Regions 2009 SME Statistics", Department for Business, Innovation and Skills. Crown Copyright.
- Desai, P (2010) "One planet communities: a real-life guide to sustainable living", Wiley, Chichester.
- European Commission Enterprise and Industry (2009) "Report on implementation of the SME definition", European Commission staff working document, Brussels.
- Holland, L and Gibbon, J (1997) SMEs in the metal, manufacturing, construction and contracting service sectors: environmental awareness and actions. "Eco-Management and Auditing", **4**, 7-14.
- IPCC Fourth Assessment Report (AR4) (2007) "An Assessment of the Intergovernmental Panel on Climate Change", IPCC, Geneva, Switzerland.
- Murray, P and Murray, S (2007) Promoting Values in Careers-based Programmes – A Case Study Analysis. "International Journal of Sustainability in Higher Education", **8**(5), 285-300
- Murray, P E (2009) Personal education for sustainable development: The way forward for sustainable construction? "Sustainability in the Built Environment", ARCOM Doctorial Workshop, University of Plymouth.
- Rees, W (2009) The ecological crisis and self-delusion: implications for the building sector. "BR&I", **37**(3), 300-311.
- Revell, A (2007) The ecological modernisation of SMEs in the UK's construction industry. "Geoforum", **38**(1), 114-126.
- Sommerville, J and McCarney, M (2003) Strategic objectives of firms within a UK construction paradigm: the impact on the micro-enterprise objectives. In: Proverbs, D (Ed.), "Procs of Construction and Building Research (COBRA) Conference", 1-2 September 2003, University of Wolverhampton, UK. RICS Foundation, 16-23.
- Sommerville, J and Thomas, W (2009) Factors affecting the management of micro-construction enterprises. In: Dainty, ARJ (Ed.), "Procs of 25th Annual ARCOM Conference", 7-9 September 2009, Albert Hall, Nottingham. ARCOM, **2**, 1349-55.
- The Royal Academy of Engineering (RAENG) (2010) "Engineering a low carbon built environment - The discipline of Building Engineering Physics", London, UK.

- Thorpe, D, Ryan, N & Charles, M B (2008) Environmental sustainability - a driver for innovation in construction SMEs? In: "Procs of 3rd International Conference of the CRC for Construction Innovation: Clients Driving Innovation: Benefiting from Innovation", 12-14 March 2008, Gold Coast, Australia.
- Walthamstow, A (2009) "Review of Rethinking Construction: Never waste a good crisis", Constructing Excellence, Warwick House, London.
- Wheeler S, M (2004) "Planning for sustainability: creating liveable, equitable and ecological communities", Routledge, London.
- Will, M (2007) Talking about the future within an SME? Corporate foresight and the potential contributions to sustainable development. "Management of Environmental Quality: An International Journal", **19**(2), 234-242.