

DELIVERING SCHOOL BUILDINGS USING OFF- SITE CONSTRUCTION: STAKEHOLDERS PERCEPTIONS

Chris Boothman¹, Anthony Higham² and Aaron Scott¹

¹*Engineering Sports and Sciences Group, University of Bolton, Deane Road, Bolton UK*

²*Department of the Natural and Built Environment, Sheffield Hallam University, Howard Street, Sheffield UK*

Following the calls from the OECD and the James review for the increase in the use of standardisation and modern methods of construction in the delivery of new school buildings. The paper sought to appraise the views of both construction and educational professionals on the use of standardised schools delivered predominantly by the use of off-site techniques and modern methods of construction. 120 questionnaire surveys were issued, to both construction and education professionals located with the north of England eliciting their views on the use of modern methods of construction. Fifty completed questionnaires were returned, representing a response rate of 42%. Analysis of the completed questionnaires revealed that the majority of the respondents support the use of both standardised schools and modern construction techniques. Whilst bespoke school design and stakeholder engagement remains important, the respondents suggested improved pedagogical outcomes, enhanced comfort, value for money and a reduction in the number of defects would be critical to the eventual success of the project. To conclude the research revealed that both the construction and education professionals surveyed are not adverse to the adoption of modern methods of construction or the use of standardised school designs proposed in the James Review.

Keywords: modern methods of construction, off-site construction, education.

INTRODUCTION

Over the last fifteen years successive reports (Egan, 1998; Wolstenholme, 2009) have called for the increased adoption of standardisation and off-site manufacture through the construction industry. Following the publication of the Government Construction Strategy (Cabinet Office 2011) which mandates the public sector to achieve significant time and cost efficiencies between 2011 and 2020. Together with the highly influential James Review which again called for the adoption of standardisation and off-site manufacture. The latest Department for Education (2014), design guidance strongly encourages the use of both standardised design and off-site manufacture for all future capital school building projects as the primary way of achieving both value for money and the government's construction targets. Taken together with the realisation that budget caps imposed by the Department of Education (2014) would make it difficult if not impossible to deliver new school buildings without some level standardisation and off-site manufacture would appear inevitable.

¹ JCB1@Bolton.ac.uk

The influential James Review together with subsequent design guidance published by the Department for Education (2014) strongly encourages the use of both standardised design and off-site manufacture for all future capital school building projects. It was therefore resolved to investigate how both construction and education professionals view the use of standardised schools, delivered predominantly using modern construction techniques to evaluate whether the rhetoric of the James Review can be realistically achieved in practice. The paper is structured so that relevant literature related to modern construction techniques, and off-site construction methods is reviewed to establish current levels of knowledge and make the case for further empirical data to be collected through a questionnaire survey. The work concludes that both construction and education professionals would welcome an increased use of off-site manufacture to further enhance the quality of new school buildings.

CONTEXT

Modern Methods of Construction (MMC) are being widely used in the UK particularly for housing as they can represent a saving in both project duration and material usage whilst also producing higher standards of quality (LABC 2013). This combination of benefits, led both Barker (2004) and Callcutt (2007) to call for the increased use of MMC's in the UK housing sector has a potential solution to the delivery of the government's new homes target by 2020. Yet, the work of LABC (2013) suggested that the benefits of using MMC's are not restricted to the domestic market, however, they may not be sufficiently adaptable to cope with the complexities of more flamboyant architectural styles or the specific requirement of some local authority planning policy documents, in which case, standardised designs and enhanced planning guidance may be needed.

Defining modern methods of construction

MMC is a universal term used within the construction industry to describe any method of building other than those considered traditional, namely standard brick and block cavity construction with or without a steel or concrete frame. However, Kempton (2009) avows there is significant difficulty defining MMC's within the current construction management literature. Indeed Kempton (ibid) identifies that a number of other terms are commonly used by construction professionals, when referring to MMC's, these include offsite construction, offsite manufacture, modular construction and prefabrication. Vokes and Brennan (2013) further suggest the terms identified by Kempton (2009) are often substituted interchangeably with each other in both the academic literature and construction practice. Despite this confusion, the BRE (2009) advances a highly generic definition, asserting that modern methods of construction can be seen as "*a range of processes and technologies which involve prefabrication, offsite assembly and various forms of supply chain specifications*". Despite the lack of a universal definition for offsite construction, Goodier and Gibb (2007) suggest there are only four widely accepted categories of off-site manufacture (see figure 1) stemming from other manufacturing industries (Vokes and Brennan 2013).

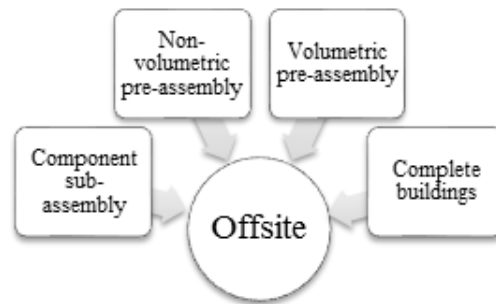


Figure 1: Four categories of off-site manufacture after Vokes and Brennan (2013)

The four main categories highlighted by Goodier and Gibb (2007) are complete buildings, volumetric pre assembly, non-volumetric pre assembly and component sub-assemblies, these categories are further defined in table 1.

Table 1: The four main categories of off-site manufacture (Vokes and Brennan 2013)

| Category | Description |
|----------------------------|--|
| Complete buildings | Units that enclose usable space and actually form part of the completed building or structure (units may or may not incorporate modular coordinated dimensions); typically fully factory finished internally (and possibly also externally). |
| Volumetric pre-assembly | Units that enclose usable space that are then installed within or onto a building or structure; typically fully finished internally. |
| Non-volumetric preassembly | Large category of items that the designer has chosen to assemble in a factory before installation; units do not enclose usable space; applications may be skeletal, planar or complex. |
| Component Sub-Assemblies | Relatively small scale items that are invariably assembled offsite, such as light fittings, doors, windows, door furniture |

Historical development of MMC

The use of offsite construction in the UK dates back to Roman times, however, it is most commonly associated with the pre-fabricated post war construction of the 1950s (Vokes and Brennan 2013). Waskett's (2001) influential review charts the early origins of prefabrication in the UK, importantly the review documents the combined pressures of slum clearance, materials shortages and post-war ruin had significantly affected housing supply, faced with increased short-term demand the government bowed to political pressure and adopted pre-fabrication as a stop gap to ease supply-side shortages. A view reinforced by Taylor (2010) who opined that despite arguments to the contrary, prefabricated housing was no cheaper over its life cycle than traditionally built housing; it simply provided a fast and efficient solution. Indeed once the market reached equilibrium and materials shortages eased constructors reverted to traditional approaches (Waskett 2011). In his evaluation of post-war prefabricated housing for Council of Mortgage Lenders Ross (2002) opined that in itself the housing was adequate, however, disasters such as Rowen Point and the concerns over quality documented by World in Action, led to a demise of confidence in non-traditional housing, together with the inability to retrofit such properties for modern living they quickly became obsolete.

However, today the use of off-site construction is largely driven by technological advances within the sector, with modern methods of construction described as the “*new products and technologies*” that result in “*delivery methods which set out to improve product and process*” (CIC, 2013). With the BRE (2003) asserting that

MMC's have the potential to introduce greater efficiencies into the construction process, through innovation in building design and management. However, Taylor (2010) opines that the use of factory based systems, typically associated with MMC's are not particularly suitable for one off buildings, suggesting design standardisation would also be needed.

Despite these limitations, the UK construction sector has increasingly adopted off-site manufacture, with 12% of all construction output now taking place in a factory or other off-site facility (Taylor 2010). However, this figure remains highly subjective as the actual value of offsite construction varies depending on the method and definition used to measure the industry. Gambin (2012) for instance suggests the true estimate to be nearer 7%. Yet, even at Gambin's lower estimate this still equates to an economic contribution in excess of £6bn (Vokes and Brennan 2013). A contribution which is likely to rise significantly over the forthcoming decade as the construction industry recovers from recession and the long term implications of a lack of training and skills development start to impact.

Use of MMC's in educational buildings

The time constraints and other restrictions associated with building schools require designers to adopt innovative approaches that are intended to increase the speed and efficiency. This can be achieved using MMCs and offsite construction given the numerous benefits MMCs offer, including enhanced quality, faster construction time, together with reductions in both construction waste and the number of defects discovered at handover. These benefits led to the Organisation for Economic Co-operation and Development (2011) to undertake a comprehensive evaluation of the use of MMCs for the construction of new schools throughout the world. The review concluded that the UK is significantly behind other nations who have actively promoted the use of off-site manufacture and standardised design. The benefits of using MMCs for school building are however, highlighted in the work of Pons *et al* (2010) who's mixed method evaluation of 200 schools constructed in the Spanish region of Catalonia using industrialised technologies discovered that the adoption of modern construction methods reduced the construction project duration and delivering a higher quality of finish whilst also reducing the environmental impact of the building. However, in the longer term, the work concluded that the use of modern methods of construction had neither enhanced nor detracted from the overall pedagogical performance of the building users. Despite the apparent lack of pedagogical benefit the James Review of England's school building programme for the Department for Education concluded that the use of modern construction methods is now a necessity given the budgetary and time savings achievable.

The literature reviewed above has examined the growth in the use of modern methods of construction, whilst identifying that the UK is significantly behind the rest of the world in their use for the delivery of new school buildings. As a result this study resolved to evaluate the perceptions of both construction and education professionals towards the increasing use of modern methods of construction.

RESEARCH DESIGN

Punch (1998) indicated that the research approach adopted for a study needed to reflect the nature of the research problems identified and the research paradigm used in previous work on a topic. Given the aims of the work established as a result of the literature reviewed above and the nature of previous work in the topic area it was

resolved to adopt a pragmatic research approach. A quantitative research design was developed that made use of a measuring instrument to collect data from a large number of practitioners. Creswell's (2003) rationale for the selection of appropriate quantitative tools indicated that a questionnaire survey was the most appropriate data collection tool for this study.

The questionnaire survey was issued to a sample of construction professionals (n=60) and teachers (n=60), working in both primary and secondary schools throughout the North of England. Due to the resource constraints of the researchers, the sample was one of convenience, defined by Bettanglia (2008) as a nonprobability sample in which people are sampled simply because they are 'convenient' sources of data for the researchers. As such the sample consisted of construction professionals and teachers with whom the third author had already established contact. In total 50 usable questionnaires were returned, giving a response rate of 42 per cent. The respondents included 26 construction professionals and 24 education professionals consisting of teachers, deputy head and head teachers. This response rate was achieved following an initial posting and follow-up e-mail communication.

MAIN FINDINGS

The importance of bespoke design in school projects

One of the first areas the questionnaire sought to evaluate related to the views of both construction and education professionals on the move away from the bespoke design of school building programmes, recommended by the James Review (James, 2011). Based on anecdotal evidence from a range of articles in the education press, it was hypothesised that neither teachers nor construction professionals would be supportive of such a move. Question six addressed this by asking respondents to consider and rate the following statement "*Bespoke design and individuality are important in school design*" with strongly agree, coded 5 and strongly disagree coded 1.

The modal response obtained from both groups of professionals was: "*disagree*". These results suggest that the majority of the sample feel that bespoke design is integral to the delivery of new school buildings. Given this finding counters the evidence provided in the James Review, it was resolved to investigate whether a significant difference existed between the two groups and whether any observed difference had occurred by chance. A null hypothesis was developed that predicted that there would be no significant difference between the two groups of professionals relating to the importance of bespoke design. A Mann-Whitney U test was conducted to evaluate the hypothesis; the results of the test were in the expected direction and statistically significant, $z=-2.635$, $p<0.01$. Construction professionals had an average rank of 30.46, while educational professionals had an average rank of 20.13 and so the analysis revealed the null hypothesis could be rejected. As such this work can conclude that despite the growing body of evidence supporting the adoption of standardised construction techniques, both construction and education professionals remain dismissive of the techniques used in an educational setting.

Role of stakeholders in the design of schools.

Engaging wider stakeholders in the design of new school buildings has been a major focus of major capital investment schemes since the commencement of the BSF program which strongly advocated the use of participatory design processes (Woolner, 2009). As such, this survey collected data from two respondent groups looking at the importance of involving pupils and other stakeholders in the design of new school

buildings through a participatory design process. Using a five point likert scale, with the mid-range response being "neither agree nor disagree", survey respondents were asked to rate the importance of teacher and pupil involvement in the design of school buildings. As figure 2 shows, of the 26 construction professionals responding to the survey, only 53% ranked stakeholder involvement as either important or very important, whereas 92% of the 24 teachers responding to the survey felt stakeholder involvement was either important or very important.

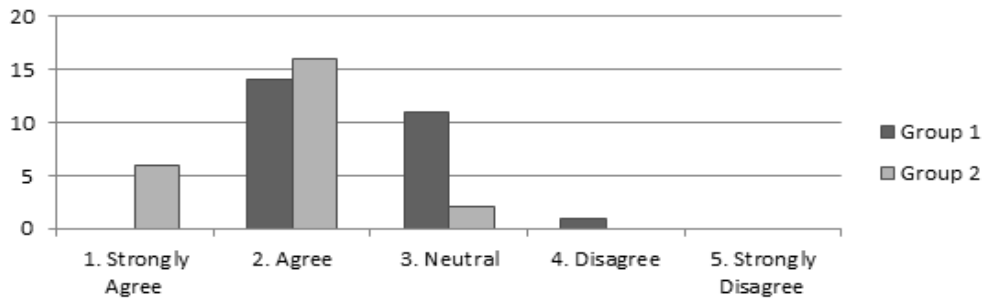


Figure 2: The importance of stakeholder involvement in school design

These results show that, whilst the majority of the teachers (group 1) surveyed felt encouraging stakeholder involvement in the design of school buildings was important, this however, this view was not as strongly supported by the construction professionals (group 2) surveyed.

It was therefore resolved to investigate whether this possible association was statistically significant. A null hypothesis was developed that predicted there would be no significant relationship between the respondents' role and their views of the involvement of stakeholder involvement in the design of school buildings. A Cramer's V test was conducted to establish if any significant relationship existed. The value of the coefficient revealed a modest association ($V=0.516$) and the significance was less than 0.05 ($p<0.01$) indicating that the null hypothesis could be rejected. Suggesting that despite teachers identifying that they and their pupils should play a significant role in the design of new school buildings, this view was not supported by construction professionals engaged to deliver such projects.

Using standardisation and off-site construction for educational buildings

The latest Department for Education (2014) design guidance strongly encourages the use of standardised design and off-site manufacture for all future capital school building projects as the primary way of achieving both value for money and the government's construction targets. In light of this, a key area of this study was to evaluate whether education and construction professionals support the use of off-site, standardised school buildings.

To answer this objective the questionnaire initially sought to evaluate the two groups understanding of 'prefabricated, standardised construction'. Based on anecdotal evidence discovered during the review of the literature it was suspected that construction professionals would exhibit a strong awareness and understanding of 'prefabricated, standardised construction'. Whereas the researchers suspected that due to their lack of specialist construction knowledge, the teachers surveyed would be unfamiliar with either approach. It was therefore hypothesised that construction professionals, would have a greater understanding of offsite construction. Question number eight addressed this area by asking the respondents to rate the following statement "I understand the meaning of both standardised and off-site construction?"

Five possible responses were offered ranging from "strongly agree" through to "strongly disagree". As figure 3 shows, all the respondents to the survey felt they had a good understanding of 'standardised and off-site construction methods' suggesting the null hypothesis cannot be rejected.

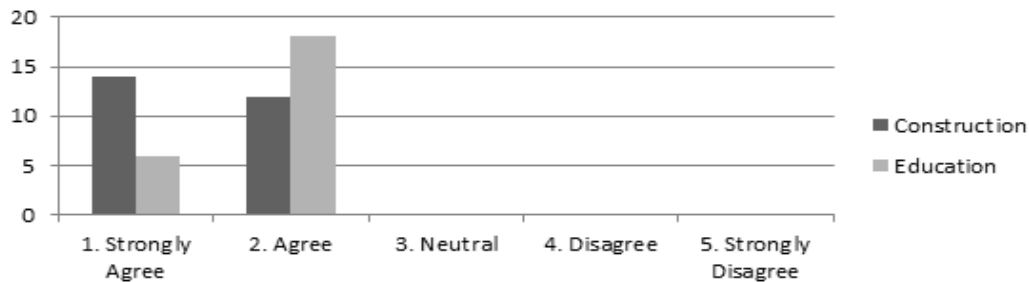


Figure 3: Survey respondents understanding of standardised and off-site construction

Finally it was resolved to investigate whether this understanding of off-site and standardised construction would influence either groups' propensity to support increasing levels of standardisation and off-site manufacture in the delivery of school buildings. Of the 50 professionals responding to the survey only 5 disagreed with the statement "Off-site, standardised construction techniques should be used for the delivery of new school buildings". The survey showed that 81% of construction and 63% of education professionals would welcome the increased use of modern construction practices if they formed part of a bespoke design.

Given the strength of support for off-site construction it was resolved to investigate whether these observations had indeed influenced the results reported earlier. The null hypotheses predicted there would be no significant relationship between the use of modern construction methods and the perceived need to deliver more new school buildings. A Cramer's V test was conducted to establish if any significant relationship existed, with the alpha set at 0.05. The value of the coefficient revealed a modest association ($V=0.312$), however the significance was above the alpha ($p<0.18$) suggesting the null hypothesis cannot be rejected. Allowing the researchers to conclude that despite the governments' assertion that all new school buildings would need to embrace some level of standardisation and off-site manufacture this was not influencing the respondent's support of modern methods of construction.

Success criteria for school buildings

Given the strong link between knowledge generation, educational attainment and buildings identified in the literature, a key area of investigation for this study was to evaluate the importance of a number of success criteria emerging from Barrett *et al's* (2012) work reviewing classroom design, the James Review (2011) and the Department of Education's (2014) school design guidance. These included: (1) the use of bespoke designs for schools, (2) internal comfort including: heating, acoustics, air quality, levels of natural light etc, (3) sustainability, (4) educational achievement and finally (5) value for money.

To identify how important these factors are to the delivery of new school buildings, the survey asked respondents to score each of the listed factors on a scale of 1 to 5, where 1 was the least and 5 was the most important. From the responses, a total score for each factor was calculated and then ranked accordingly with the factor in position one deemed to be the most important as shown in tables 2 and 3.

As table 2 and 3 show; improved results, internal comfort and value for money were seen as essential outcomes for any capital development project, with both groups ranking improvements in educational attainment as the most important measure of success for finished school buildings (122 and 117). However, despite the earlier analysis highlighting the importance of bespoke design, neither group of respondents felt adopting a bespoke design would influence the eventual success of the project.

Despite the apparent levels of agreement between the two groups towards of the five success criteria, it was nevertheless resolved to establish whether a significant difference existed between the two groups' opinions of success to see whether their professional outlook or experience of school buildings affected the way they viewed success using a further Mann-Whitney U test. For the majority of the variables, the test revealed an insignificant difference between the groups suggesting a consensus of opinion as to the importance of the majority of the success measures. However, the scores for 'internal comfort' revealed a statistically significant difference between the two groups ($z=-1.991$, $p=0.047$) with teachers suggesting internal comfort to be a far more important measure of success.

Table 2: Ranking of Success Criteria by Construction Professionals

| | (1) | (2) | (3) | (4) | (5) | Cumulative total | Ranking |
|------------------|-----|-----|-----|-----|-----|------------------|---------|
| Improved Results | 0 | 1 | 1 | 3 | 21 | 122 | 1 |
| Value for Money | 3 | 6 | 5 | 9 | 3 | 81 | 2 |
| Sustainability | 1 | 8 | 7 | 9 | 1 | 79 | 3 |
| Comfort | 1 | 6 | 13 | 5 | 1 | 71 | 4 |
| Bespoke Design | 21 | 5 | 0 | 0 | 0 | 37 | 5 |

Table 3: Ranking of Success Criteria by Teaching Staff

| | (1) | (2) | (3) | (4) | (5) | Cumulative total | Ranking |
|------------------|-----|-----|-----|-----|-----|------------------|---------|
| Improved Results | 0 | 0 | 1 | 1 | 22 | 117 | 1 |
| Comfort | 0 | 4 | 7 | 11 | 2 | 83 | 2 |
| Value for Money | 3 | 11 | 3 | 6 | 1 | 63 | 3 |
| Sustainability | 6 | 4 | 9 | 5 | 0 | 61 | 4 |
| Bespoke Design | 15 | 5 | 4 | 0 | 0 | 37 | 5 |

DISCUSSION

Whilst the paper is unable to reach firm conclusions on the use of off-site manufacture and standardised school designs due to the limitations associated with the small sample size. The findings from the study reveal that, contrary to expectations, the gap between the rhetoric communicated through both the influential James Review and the subsequent Department for Education (2014), design guidance, which strongly encourages the use of both standardised design and off-site manufacture for all future capital school building projects and the realities of practice, is reducing. With 63% of teachers and 81% of construction professionals responding to the survey supporting the use of some level of off-site manufacture as part of any new school building on the proviso that off-site manufacturing is adopted alongside a bespoke design. This

finding, however, contradicts the more generalised findings reported by Wolstenholme (2009) in his review of progress since the highly influential Egan report. Wolstenholme observed a very low uptake of off-site manufacture especially in the housing sector despite the calls for increasing engagement with off-site techniques to accelerate supply (Barker 2004) and enhance quality and customer satisfaction (Callcut 2007) appear to have failed due to the end clients continued lack of understanding. This suggested the client represented a substantial barrier to an increased use of off-site manufacture. However, this study suggests these barriers are starting to be overcome, with education professionals responding to the survey demonstrating an increased willingness to embrace off-site manufacture.

However, despite this commitment to off-site manufacturing, the second key recommendation from the James Review relating to the adoption of standardised school designs continues to represent a major gap between the governments' rhetoric and the realities of practice. Despite the appraisal of standardised schools designs within this survey focusing mainly on stakeholder engagement, given this remains a major legislative requirement under the Education Act 2002. Analysis of data revealed that whilst construction professionals were dismissive of stakeholder involvement in school delivery, 93% of education professionals responding did identify stakeholder involvement to be an important aspect of project delivery. A view supported by Higgins *et al's* (2005) exhaustive review of literature which concluded, that on balance, school pupils and staff can play a significant and positive role in the delivery of effective learning environments, which may be lost if standardised designs are implemented. Yet despite the strength of support for bespoke design, on the grounds of stakeholder engagement, neither group of respondents felt adopting a bespoke design would ultimately be important to the eventual success or otherwise of the project. Instead the respondents suggested the buildings ability to enhance educational attainment, internal comfort and the projects ability to deliver value for money would be more significant measures of success.

CONCLUSIONS

The paper sought to appraise the views of both construction and educational professionals on the use of standardised schools delivered predominantly by the use of off-site modern methods of construction techniques. Whilst the majority of the respondents felt a bespoke school design undertaken in consultation with various stakeholders remains important issues such as improved results, enhanced comfort and value for money are more critical to eventual success. Albeit the traditional methods of construction are still seen to be the preferred method, the respondents are not adverse to the use of standardised construction and off-site manufacture if the end product enhances the overall quality of the learning environment and ultimately enhances educational attainment. Finally, given the limitations of both the data collection strategy and sample size, the results obtained cannot be deemed to be representative of the population as a whole but merely of the sample.

REFERENCES

- Bettanglia, M (2008) Convenience sampling. In: Lavrakas, P J (Ed) *"Encyclopaedia of survey research methods"*. Unknown: Sage.
- Barker, K (2004) *"Barker review of housing supply. Delivering stability: securing our future housing needs"*. London: HM Treasury and ODPM.

- Barrett, P, Zhang, Y, Moffat, J and Kobbacy, K (2013) A holistic, multi-level analysis identifying the impact of classroom design on pupils learning. *"Building and Environment"*, **59**, 678-689.
- Building Research Establishment (2003) *"Current Practice and Potential Uses of Prefabrication"*. Watford: BRE
- Building Research Establishment (2009) *"Modern Methods of Construction"*. Watford: BRE
- Cabinet Office (2011) *"Government construction strategy"*. London: Cabinet Office.
- Callcutt, J (2007) *"The Callcutt review of house building delivery"* London: DCLG.
- Construction Industry Council (2013) *"Offsite Housing Review"*. London: CIC
- Creswell, J.W. (2003) *"Research design: Qualitative, quantitative and mixed methods approaches"*. 2ed. London: Sage Publications.
- Department for Education (2014) *"School capital building programmes and the priority school building programme"* London: DfE.
- Egan, J (1998) *"Rethinking construction"* London: Constructing Excellence.
- Gambin, L. (2012) *"Sector Skills Insights: Construction. Evidence Report 50"*. London: UKCES.
- Goodier, C.I. and Gibb, A.G.F. (2007) *"Future opportunities for offsite in the UK"* Loughborough: Loughborough University.
- Higgins, S, Hall, E, Wall, K, Woolner, P and McCaughey, C (2005) *"The impact of school environments: A literature review"*. Newcastle: University of Newcastle.
- James, S (2011) *"Review of education capital"*. London: DfE.
- Kempton, J and Syms, P (2009) Modern Methods of Construction: Implications for Housing Asset Management in the RSL Sector. *"Structural Survey"*. **27**(1), 36-45.
- LABC (2013) *"Technical Manual, Version 6"*. London: LABC.
- Organisation for Economic Co-operation and Development (2011) *"Standardised Design for Schools: Old Solution, New Context?"* Paris: OECD.
- Pons, O, Oliva, J, and Maas, S (2010) Improving the learning process in the latest prefabricated school buildings. *"Improving Schools"*. **13**(3), 249-265.
- Punch, K (1998) *"Introduction to Social Research: Quantitative and Qualitative Approaches"*. London: Sage Publications.
- Ross, K. (2002). Non Traditional Housing in the UK - A Brief Review. Watford: BRE.
- Taylor, M (2010) A definition and valuation of the UK offsite construction sector, *"Construction Management and Economics"*, **28**(8), 885-896
- Vokes, C. and Brennan, J. (2013). *"Technology and Skills in the Construction Industry"*. Rotherham: UKCES.
- Waskett, P. (2001) DTI Current Practice and Potential Uses of Prefabrication. Watford: BRE.
- Wolstenholme, A (2009) *"Never waste a good crisis"* London: Constructing Excellence.
- Woolner, P J (2009) Building Schools for the Future through a participatory design process: exploring the issues and investigating ways forward. In: Durant, D (Ed) *"BERA Annual Conference 2009"*, 2-5 September 2009, University of Manchester. British Educational Research Association.