



Original Article

Integrating Building Information Modeling and Health and Safety for Onsite Construction



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ARTICLE INFO

Article history:

Received 25 April 2014

Received in revised form

30 September 2014

Accepted 8 October 2014

Available online 18 October 2014

Keywords:

building information modeling

communication

construction

health

safety

ABSTRACT

Background: Health and safety (H&S) on a construction site can either make or break a contractor, if not properly managed. The usage of Building Information Modeling (BIM) for H&S on construction execution has the potential to augment practitioner understanding of their sites, and by so doing reduce the probability of accidents. This research explores BIM usage within the construction industry in relation to H&S communication.

Methods: In addition to an extensive literature review, a questionnaire survey was conducted to gather information on the embedment of H&S planning with the BIM environment for site practitioners.

Results: The analysis of responses indicated that BIM will enhance the current approach of H&S planning for construction site personnel.

Conclusion: From the survey, toolbox talk will have to be integrated with the BIM environment, because it is the predominantly used procedure for enhancing H&S issues within construction sites. The advantage is that personnel can visually understand H&S issues as work progresses during the toolbox talk onsite.

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1. Introduction

The Plan for Growth by the Government in the UK, published alongside Budget 2011, emphasized the significance of an efficient construction industry in the country to the economy. Construction accounts for about 7% of the gross domestic product—or £110 bn of expenditure per year—with approximately 40% of this being in the public sector, with Central Government being the biggest customer of the construction industry [1].

The construction industry is well known as one of the most dangerous in which to work [2]. Despite the fact that the UK construction sector only accounts for approximately 5% of employees in Britain, 27% of all reported occupational fatalities and 10% of major injuries are from the construction industry, as reported by the Health and Safety Executive (HSE), the body that manages health and safety (H&S) in all sectors of the UK [3].

Most of the recommendations proposed by Sir John Egan in “Rethinking Construction” in 1998 have now been implemented by the construction industry. However, most large construction firms

have made a tremendous effort to achieve the recommendation of a 20% reduction in accidents. Although problems exist with construction firms that make up the bulk of the industry, the awareness remains among practitioners and academics in finding innovative solutions to address most of what was said in the Egan report. The HSE has also made progress in the areas of H&S regulations, guidelines, and approved codes of conduct, as well as creating H&S awareness among construction practitioners.

As construction projects increase in complexity, alternative modern methods of construction and design increase in popularity [4]. These new, complex construction projects require new forms of innovation in design and methods of construction. To address this matter, Suermann [5] pointed out that building information modeling (BIM) can be used by designers, construction managers, and contractors to accomplish tasks more efficiently than ever before and pave the way for future construction professionals.

Hence, with the development of BIM and the life cycle realization of the project in one holistic environment, most of the H&S information can be created directly in this single environment.

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These are some of the advantages that this article intends to explore in relation to the use and application of the integrated approach within the four-dimensional (4D) modeling for the benefits of most site workers.

The research questions for this article will only address the issues of H&S on a construction site, as well as investigating the position of practitioners' perception with respect to site operatives on BIM usage for H&S on-site construction.

In the wider literature there are many definitions of what BIM is, and in many ways it depends on the point of view of who looks at it or what is sought to gain from the approach [6–8]. However, in the UK, the Construction Project Information Committee (CPIC) has defined BIM 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" [9]. Hence, for this article we view BIM as a "catalyst" for site practitioners and operatives to improve and enhance their safety concerns and their understanding of the dynamic site environment, as they carry out work activities.

The goal of this article is to answer the question: "How can BIM enhance the continuous improvement of Health and Safety on construction site?".

2. Materials and methods

The methodology used in this article followed a traditional literature review approach to understand the development of BIM technology up to its current status. The approach, however, concentrates on the thematic analysis of literature in which relevant themes affecting the application of BIM onsite are investigated. For each research theme, the classic and contemporary theory that underpins each is first investigated, and then the literature review that is undertaken is couched within the theoretical underpinning framework. This work starts with the literature review on communication theories with particular references to H&S on construction sites. An intensive literature search was conducted on the following main themes: BIM innovation; H&S implementation; and communication issues on construction sites. The three themes were then brought together to understand important factors as well as barriers of H&S communication on construction site. These themes were further explored and validated in a questionnaire survey sent to practitioners.

A questionnaire was used to facilitate the collection of information from construction firms. It covered issues relevant to H&S performance as well as those related to BIM. The allocation of items to domains was a matter of judgment but was guided by discussions with H&S practitioners within the built environment and the HSE itself, as well as by previous surveys carried out on this subject. To a certain extent, the different statements used in developing the questionnaire were based on scales that had been previously used by researchers [10–16].

All the survey questions were measured through a Likert-type response format. Properties relating to each of the survey questions were used in the form of statements to measure personnel's understanding of the topic under investigation. Participants were asked to endorse the statements using a 5-point Likert-type scale from 1 "strongly disagree" to 5 "strongly agree".

The draft questionnaire was reviewed by five practitioners, which gave the questions a better content validity, prior to the distribution of the survey questionnaires to the chosen organizations. The self-administered questionnaires were distributed to a sample of 200 construction practitioners in the UK in mid-2012. The sample was randomly selected from the top 1,000 practitioners based on their annual turnover. Altogether, 46 questionnaires were

returned and analyzed, giving a response rate of 23%, which is an acceptable return for a questionnaire survey [17].

Prior to sending the questionnaire out by postal mail to senior personnel, the data reliability and validity were tested. Data reliability is associated with the data source, data collection instrument, and the quality of the communicated questionnaire, as well as the identification of the position held by the respondent [18,19]. Based on the profile of the respondents, the direct mailing to individuals in organizations seemed to have achieved its objective of reaching those who were closely involved with delivering construction projects. Posting to organizations in different regions of the UK minimized the duplication of selected projects. All 46 respondents provided their business details, which revealed that all held senior positions within their organizations and have influence in the management of H&S.

2.1. Communication in construction

There are several theories of communication [20–23]. In this article a perspective of these theories is taken that aligns itself with the practices of the construction industry. The theories of communication more suited to construction are the linear approach, the interactional approach, and the transactional approach. The linear approach suggests that the person is only a receiver or a sender. The interactional model of communication emphasizes the two-way communication process between the communicators. In other words, communication goes in two directions. This circular process suggests that communication is ongoing. The transactional approach underscores the simultaneous sending and receiving of messages in a communicative episode. To say that communication is transactional means that the process is cooperative; sender and receiver are mutually responsible for the effect and the effectiveness of communication. In the linear model of communication, meaning is sent from one person to another. In the interactional model, meaning is achieved through feedback of sender and receiver. In the transactional model, people build shared meaning [21].

Communication also includes both the communication medium and the core knowledge which form the basis for mutual understanding of team participants. Bennett [24] has stated that there are two categories of interaction that match the basic characteristics of teams. The first is concerned with the communication of information. Information should be first translated into text or graphics that the other team is likely to understand. These texts or graphics need to be communicated to the other team through a communication medium [25–27]. The second category of interaction is the one concerned with work organization. Clear organization of work allows the work of teams to fit together. In other words, teams should coordinate their actions.

In the construction industry, site teams and other participants in construction projects communicate using traditional methods such as face-to-face meetings, paper-based drawings, schedules, written statements. The construction industry displays some inertia in changing its methods of communicating and innovating through adopting new technology. The use of telecommunication systems such as facsimile, e-mail, and mobile phones has improved the communication in respect of speed, but it has not influenced the efficiency of the process or the quality of information exchange [28,29], especially with respect to H&S of all the workers onsite. In recent times there have been great leaps in technology for onsite communication, with the introduction of wireless internet, personal digital assistant (PDA) systems, internet protocol communications, and computer-aided design, as well as BIM technology and innovations. The knowledge about such new technologies is prevalent within the industry but tends to concentrate in its upstream end, that is the design and consultancy area, as well as in educational

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