

Article

Opportunities for Using Building Information Modeling to Improve Worker Safety Performance

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Abstract: Building information modelling (BIM) enables the creation of a digital representation of a designed facility combined with additional information about the project attributes, performance criteria, and construction process. Users of BIM tools point to the ability to visualize the final design along with the construction process as a beneficial feature of using BIM. Knowing the construction process in relationship to a facility's design benefits both safety professionals when planning worker safety measures for a project and designers when creating a project's design. Success in using BIM to enhance safety partly depends on the familiarity of project personnel with BIM tools and the extent to which the tools can be used to identify and eliminate safety hazards. In a separate, ongoing study, the authors investigated the connection between BIM and safety to document the opportunities, barriers, and impacts. Utilizing an on-line survey of project engineers who work for construction firms together with a comprehensive literature review, the study found those who use BIM feel that it aids in communication of project information and project delivery, both of which have been found to have positive impacts on construction site safety. Further, utilizing the survey results, the authors apply the binary logistic regression econometric framework to better understand the factors that lead to safety professionals believing that BIM increases safety in the work place. In addition, according to the survey results, a large percentage of the engineers who use BIM feel that ultimately it helps to eliminate safety hazards and improve worker safety. The study findings suggest that improvements in safety performance across the construction industry may be due in part to increased use of BIM in the construction industry.

Keywords: Building information modelling; worker safety; construction; econometric modelling

1. Introduction

The construction industry is an industry that comprises a large share of the national markets of developed countries. From this standpoint, addressing and improving construction industry characteristics might ease the construction process and increase profits. Doing so will ultimately have a positive impact on the economy of a respective country. Cost, schedule, quality, and safety are commonly held as the most important performance criteria of a construction project. Construction safety is unique; it affects, and is also affected by, the other performance criteria. Enhancing worker safety and health returns benefits to the project in particular and the industry in general. Accidents and other safety concerns are still issues in the construction industry that requires additional research and further steps to help prevent and solve these issues.

Increased focus on preventing injuries and fatalities and improvements in safety have occurred in recent years, however, the construction industry is still one of the three most dangerous work industries [1]. In the United States (US), there were 985 fatal injury cases in the construction industry

during 2015 in comparison with 4836 cases for all other industries which makes the construction industry responsible for approximately 20% of all of fatal injury incidents [2]. Hazardous situations that lead to accidents negatively impact the US economy. For example, the Bureau of Labor Statistics reports that compensation costs due to injuries and fatalities costs the employer US\$34.51 per hour worked in construction, maintenance, and natural resources [2]. Investment in new ways to improve construction safety is recommended, which is also beneficial to other project qualities such as cost, schedule, and quality. One mean to enhance safety performance is to use technology. Building information modelling (BIM) is one of the adopted technologies that has been increasingly used in recent years within the construction industry.

BIM is “a digital representation of the building process to facilitate exchange and interoperability of information in digital format” [3]. BIM produces a virtual model of the building digitally [4] that not only has precise dimensions of the project, but also other beneficial layers of information such as the cost of used materials and building life cycle costs [5]. Seeing the project model virtually makes it possible for the designer and/or construction engineer to discover conflicts and safety issues beforehand which can enhance the overall quality and safety performance of the project.

BIM can provide significant opportunities for reducing and eliminating safety and health issues on job sites. In fact, commercial benefits from using such technology are obvious, “but the potential benefits in improved health by reducing accidents and deaths are so great as to be almost unquantifiable” [6]. Simulation of a building or any part of a project is easier and more beneficial by using BIM. This suggests that solutions or innovations are more effective [4].

The research presented in this paper is part of a larger study that has been conducted to understand the connection and opportunities that might arise from using BIM to serve construction in general, and construction safety specifically. This research is intended to provide an understanding of the role and ability of BIM in eliminating hazardous situations on jobsites. This knowledge is gained by the construction engineers who work in the field. Moreover, the use of BIM in easing the communication process, and the impact that BIM has on project delivery, are additional areas of focus that this study aims to gain a better understanding about. The current study also aims to obtain an understanding of the industry’s general knowledge of using BIM and its impact on delivery methods. A small number of studies describe the shortcomings of using BIM, which will be touched on in the present study. Overall, this study aims to increase the focus and adoption of BIM across the construction industry which can help in discovering hazards before and during the construction phase. Promoting research on BIM in further studies may prompt stakeholders to pay additional attention to its potential benefits.

2. Literature Review

Management and other personnel who are involved in the architecture, engineering, and construction (AEC) industry have been gaining enhanced knowledge about BIM in the past few years [7]. This enhanced knowledge is likely a result of the increasing use of the technology in the construction industry, which may in turn help in utilizing BIM for predicting unfavorable events on jobsites. Construction health and safety intersects with BIM in terms of its applicability and use, which is an important additive of the technology [6]. For instance, scaffolding accidents account for 65% of construction worker accidents and has the potential to be managed and controlled by using 4D BIM, potentially reducing safety hazards [8]. Additionally, the manner in which work is conducted and the safety hazards that exist, is now based on BIM in several ways on a large number of projects [9]. In fact, there is increasing attention regarding the use of information technology in general, as well as specific BIM research for construction safety [10].

BIM can also provide great opportunities to help identify hazards and, as a result, reduce safety and health issues on jobsites. Melzner et al. [11] presented a comparative case study that was based on an automated rule-based checking system for BIM applications. Specifically, the authors focused on safety rule implementations of fall standards in Germany and the United States. Through their case study, Melzner et al. find that the rule-based checking system in BIM can detect potential fall

hazards using an industry foundation class (IFC) design model and can recommend safety protective equipment based on predefined rule sets [11]. Zhang et al. have worked on developing an algorithm that checks the model of a building and discovers the hazards present [12], which is a benefit that BIM offers to enable the model to be checked. Since their study focused on fall hazards, the work could be considered as a departure point for other researchers to investigate other types of common hazards such as being struck by objects, caught in between objects, etc. A study conducted in 2007 by Kunz and Giligan [13] found that BIM is useful in the documentation process, design improvement, and clash detection (As cited in [4]). Alomari et al. [14] stated that BIM helps create improvements in cost, cost estimation, and project duration. Furthermore, it has been found that one of the most important reasons for using BIM is the collaboration between project team members [14]. Zhang et al. [15] developed an automatic BIM-based fall hazard identification and planning tool that is able to identify potential fall hazards, assist in labor-intensive modeling, and improve workers' safety. The authors [15] also evaluate the maturity of a BIM-based tool in the context of fall prevention during building construction projects. Zhang et al. [15] found that BIM was able to detect both the potential and the location of fall hazards for concrete slabs and leading edges, as well as provide installation guidelines regarding fall protection equipment. Further, the tool developed by Zhang et al. [15] has shown to have a substantial amount of potential concerning BIM-based safety plans.

Construction safety issues arise from either work conditions and/or individual worker behavior [16,17]. In recent years, design decisions and omissions have been studied with more focus, and researchers have found that these design impacts might be root causes for incidents [18,19]. An understanding of the impacts of design on work conditions has led to the development of prevention through design (PtD) as an effective practice during the design phase to eliminate hazards on jobsites [20]. Since BIM is an effective way to accomplish the design, it may also play a noticeable role in producing safer designs utilizing the PtD concept. Qi et al. [21] developed a software that uses BIM to confirm the presence of safety requirements during design. Since behavior is one of the primary causes of accidents, integration between BIM and radio frequency identification (RFID) has been adopted to warn workers of hazardous positions [22].

Communication on a project is a very important attribute that impacts the level of construction safety. Successful communication regarding safety is a primary practice that improves safety and health in the construction industry [23]. BIM helps in the process of exchanging information among stakeholders [24]. Hanna et al. [25] stated that the use of BIM enhances coordination and reduces clashes on jobsites, this is particularly true for electrical workers. These outcomes benefit safety records since the design has been shown to have a significant impact on safety [18]. Also, clash detection eases the work process and increases the ability to eliminate safety issues on a worksite before the work commences. Safety and other project aspects such as cost and schedule are connected and have a reciprocal impact; improvement in one can be beneficial for the others. In fact, the more details that are shown in the design phase, the better the understanding of potential conflicts in design and issues regarding safety. This relationship is true from a logical point of view, and is also found to be a priority in design for safety (DfS) using BIM [26].

BIM has features that help the construction industry in general and safety improvement specifically. One feature is its ability to help reduce waste during the design phase [27]. Clevenger et al. [1] worked on 3D visualization describing a tool that is intended to enhance safety by reducing the impact of language differences on the jobsite. A safer design can be considered a sustainable design since it reduces the financial impact of injuries incidents on projects. From this point of view, Kasirossafar et al. [28] have studied the use of BIM and other visualization technologies to increase design options that result in safer and sustainable designs. A visualization that is adopted through BIM was found to be better than other DfS methods regarding construction safety improvement [26]. Other BIM features provide an advantage to the construction process during the different life cycles of the project, not just during the design phase. These beneficial attributes have led to BIM being increasingly used in different countries and is required in the UK [27].

Based on the above literature, it can be noted that there are different benefits and uses of BIM in the construction industry. However, there are shortcomings of using BIM, or restrictions on its use, that are not stated in literature. This research departs from prior studies by filling this gap in knowledge. Also, it is believed that BIM offers more benefits than those described in previous literature; hence, the present study seeks to identify those benefits that constitute advantages to construction safety. Moreover, enhancing our knowledge about using BIM is presented in this work which pushes the use of technology on a wider scale. Utilizing responses from management personnel who conduct the work on site is another additive to the literature, as some of the aforementioned documents are published books that reflect the author's perspective and are not based on industry input.

3. Research Objectives and Methods

In this study, the researchers attempt to show the possibility of having a positive or negative impact of using BIM on worker safety on construction jobsites. If the study shows a positive impact, the authors intend to promote the use of BIM as a means to improve safety. Revealing some of the shortcomings of using BIM is also an objective of this study, along with the other objectives that are stated in the Introduction.

To attain the study goal and objectives, the authors administered a survey to field engineers with different work titles, such as project manager, project engineer, safety engineer, and other engineering personnel. The sample consists of 209 construction management personnel from the Pacific Northwest region of the US. More than 50 questions were asked in the survey. However, only certain questions are used in the current study. In addition to questions about respondent demographics, other questions were stated to extract information about the opportunities and shortcomings of using BIM.

Open-ended questions were used to allow the respondent a wider range of response. The open-ended questions were complemented with a mixed of closed-ended questions. However, the closed-ended questions were developed in such a way that the respondent could add more than the provided choices. Utilizing both types of questions was intended to reduce the bias that could result from determined options in the questionnaire.

The survey provides an opportunity to gain a better understanding about construction worker safety from an engineer's perspective. A convenience sample is used for the study as it is difficult to utilize an entirely random sampling process in the construction industry. As a result, the authors have evaluated the validity and reliability of the survey to ensure confidence in the results. Institutional Review Board approval was gained for the questionnaire before its distribution as the survey targets human subjects. The on-line secure research suite Qualtrics was used to distribute the survey and collect the responses. The first step consisted of sending the survey to the chosen sample of engineers by email, and then the participants responded using the Qualtrics website. A condition was set for each Qualtrics survey link attached to the email so that only one response could be gathered from the link.

4. Results and Discussions

The results section is divided into three subsections for ease in presenting and interpreting the results. The first subsection presents the demographic information of the respondents. The second subsection describes the survey responses related to some shortcomings of using BIM from the perspective of field engineers. Lastly, the third subsection provides descriptive statistics about BIM opportunities in construction and BIM's impact on safety. Also, an econometric modelling technique was applied in this subsection to show variables that are statistically linked to the impact of BIM on the enhancement of construction safety.

4.1. Demographic Information

Forty-nine usable responses were received before the survey was closed (23% response rate). However, not all of these responses were used for further analysis. Some of the responses lacked the

required information and were therefore omitted by the researchers. Of the usable responses received, 37 (76%) contained answers to every question. The responses to the questions regarding demographic information about the respondents show that the majority of respondents are greater than 30 years old (64%). Sixty-five percent of the respondents hold a 4-year college degree while 25% hold a graduate degree. Regarding work experience, the responses show that the respondents have a wide range of experience in terms of duration. Seventy-three percent of the respondents have more than 5 years of construction experience. The majority of respondents have worked on more than 20 projects in their career. The respondents have worked on a variety of different types of projects such as educational, commercial, residential, and health facilities. Moreover, 84% of the respondents were working for a general contracting firm at the time of the questionnaire distribution. In regard to job titles, 31% hold the title of project manager while the highest percent (41%) were project engineers. Other positions held by the respondents include safety specialist, superintendent, and other management roles.

4.2. Building Information Modelling Shortcomings

It is assumed that all technology solutions come with shortcomings, and BIM is one of these solutions. The shortcomings might arise from the use of the technology itself, the conditions of the work environment in which the technology is used, or other factors. Different drawbacks of using BIM should be considered from the engineer's perspective. The most cited shortcomings are its lack of suitability for all projects and an absence of a need for BIM on all projects. Linking this result with the high cost of owning and operating the technology [14] makes sense logically as most general contractors place a high priority on the profits of their work (also, the highest percentage of the respondents were general contractor employees). In addition, required training and its associated costs is viewed by a large percentage of respondents (48%) as a shortcoming that impacts the tendency to adopt the technology. Furthermore, the resistance of people within the organization(s) is considered another shortcoming which was chosen by 42% of respondents. The respondents identified other shortcomings as well; the entire list is shown in Figure 1. The respondents provided suggestions for ways to improve and expand the use of BIM in the construction industry. Among these suggestions were educating stakeholders about the benefits and impact of using the technology. This can be accomplished by conducting workshops from the technology manufacturer and/or the governmental entities who support the idea.

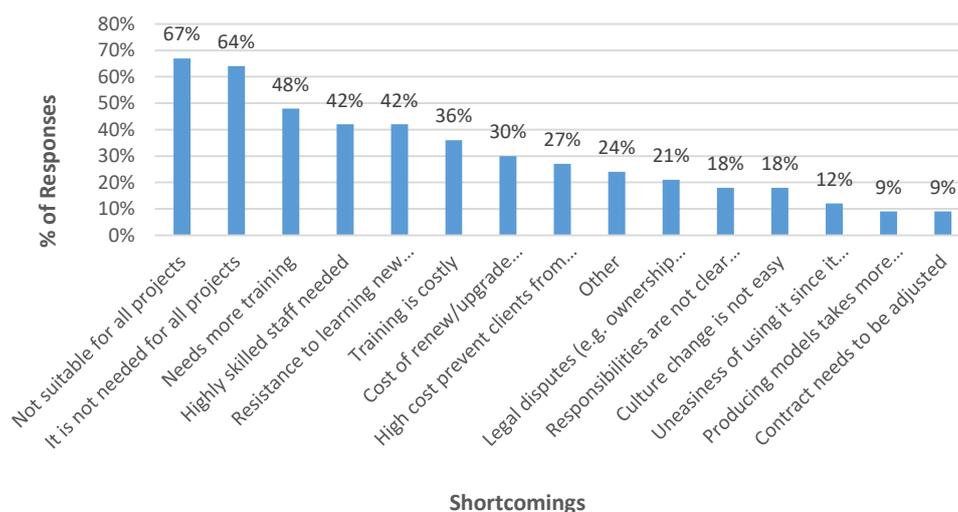


Figure 1. Shortcomings of the use of Building information modelling (BIM) by the construction industry.

The transition of an organization to adopt a new practice or technology in the workplace is not easy due to several factors and requires planning. The respondents, however, think that the

transition to a BIM environment for projects can be done safely and smoothly. Fifty-eight percent of the respondents agreed with this perspective, while 17% were unsure of the transition. On the other hand, 25% of the respondents think that it is not safe to transition to a BIM environment. Again, this result might be due to the resistance that industry and/or organizational culture has created in their minds. One of the most important aspects in the difficulty of transitioning to a BIM environment might be the interpretation of the BIM model. Those who support the transition and those who were unsure of the transition (81% of the respondents) indicated that BIM models are easy to interpret. Only 19% percent of the respondents were unsure if it is easy to interpret BIM models and no respondents think it is difficult. This result supports the idea of extending the use of BIM and the need to change the culture of resistance in the construction industry.

In this study, the researchers intended to explore the issue of using BIM in firms from a field management engineer's perspective. This procedure is intended to gauge how much the respondents consider the feasibility of implementing BIM when making decisions about BIM use. The majority of respondents (43%) believe that the decision related to feasibility depends on different factors. More than half of the 43% majority indicated that project size is the primary factor in deciding whether to use BIM or not. Other respondents considered the cost of using BIM as an important factor. Eleven of the respondents (30%) were against the idea of using BIM for all projects in all firms. This response is realistic when considering the previous reasoning about those respondents who worked on specific projects that have not used BIM. The last group is composed of those respondents who feel that all firms should use BIM. This response is not justified, in the authors' opinion, as it does not consider the feasibility of using the technology. However, the respondents might answer in this way if they have a specific measure in mind, such as considering only large and complex projects. This result requires additional investigation to gain a clearer and comprehensive understanding of the responses. Figure 2 below shows that the highest percentage of respondents think the use of BIM should depend on the needs of the firm.

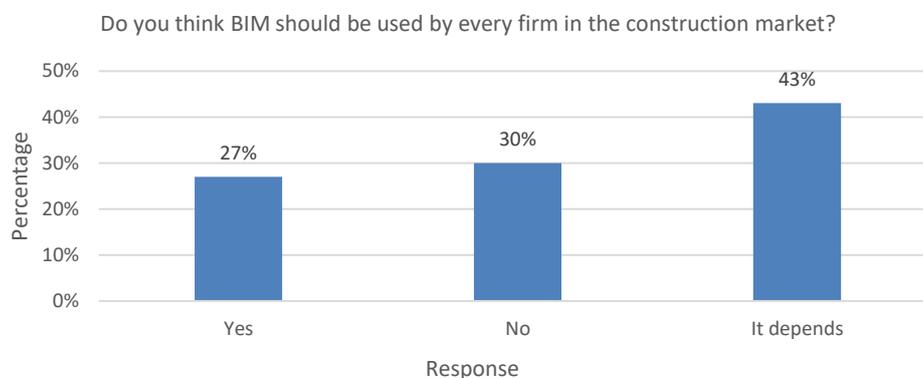


Figure 2. Responses regarding using BIM in every firm in the construction market.

The above result for those who are not in favor of using BIM in all firms might also indicate that implementing the procedures and products of BIM requires more training and testing. This issue was also assessed in the questionnaire. In fact, 70% of the respondents are divided equally between being accepting or unsure about whether BIM products should receive more testing and if more training is needed. Regarding the time needed for a firm to implement this technology throughout the firm, most respondents (55%) stated that a 1 to 3 year period is needed. This time frame suggestion is acceptable as the transition period to apply the technology in a limited range after a firm has adopted a BIM product (e.g., first for one project), then extend the use to additional projects and train people, falls within the 1 to 3 year period specified by the respondents. Thirty-two percent of the respondents believe that more than three years is required for a firm to use BIM smoothly in their work.

Regarding safety opportunities, respondents state that BIM is beneficial in discovering errors in the design earlier. Ninety-seven percent agreed that this opportunity is offered by BIM, as shown in Figure 3. This high level of agreement indicates that both field and management engineers may have experienced positive results with respect to safety from implementing BIM. The essence of this benefit might be magnified if connected with other safety and health improvement concepts. PtD is one example of these concepts.

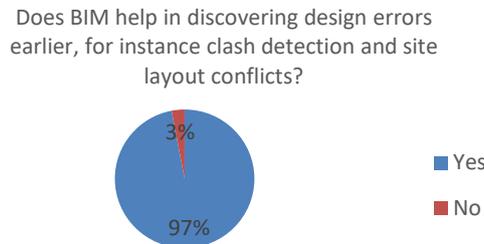


Figure 3. Impact of BIM in discovering design errors.

To ensure that the respondents were consistent with their answers, the questionnaire included a direct question regarding personnel construction safety and whether safety performance improves, as a result of reducing risk, when BIM is used. Forty-nine percent of the respondents believe safety improves when using BIM and 40% were unsure of its impact, as shown in Figure 4. A small percentage of respondents (11%) believe safety is not enhanced with the use of BIM. In fact, the portion of the 40% of respondents who indicated that they were unsure might support the statement that safety improves after using the technology if the respondents knew more about the technology. Construction safety is perceived to improve with the adoption of the technologies. Cost improvement, and reduced omissions and change orders are examples of benefits when using BIM [14]. Further, the uncertainty in their responses might be attributed to not having perceived the indirect impact of design errors on safety since their focus is on discovering errors only as shown in Figure 3. It is sometimes the case that there is still uncertainty about the direct and indirect causes of safety issues. Explaining the issue of the direct and indirect impacts of design errors on safety may lead to more positive responses to the question about whether BIM helps to enhance safety and reduce risk.

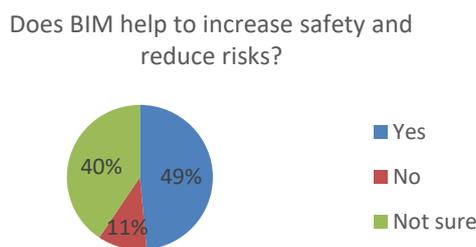


Figure 4. Impact of BIM’s use on Safety level.

The survey responses reveal that a high percentage (72%) of the respondents have stated that BIM eases communication among project parties, while 14% think that it does not and 14% are unsure. This added benefit of BIM has a significant impact on improving construction safety, which is known to improve with enhanced communication. This benefit could be cited as one motivation for educating stakeholders about BIM’s impact. Again, unsure respondents could alter their opinion to be in favor of positive BIM impacts if they have more knowledge about general construction safety research. Furthermore, the respondents generally did not state that BIM is used for safety achievement in their firms. Only 21% agreed that BIM is used for safety within their firms, which lends support to why the respondents did not state that safety achievement was a goal of implementing BIM. The organizational

culture within these firms may not support this trend. In fact, the culture may create resistance to the notion of using BIM for that purpose in addition to its other additives. Moreover, BIM has a positive impact on safety indirectly by helping to reduce omissions and discover errors earlier as stated above.

Phase suitability was also assessed in this study from the perspective of the management engineers. With respect to the phase in which it is more fitting to use BIM, most of the respondents (94%) answered that preconstruction is the most suitable phase. In fact, this answer is more practical due to safety influence being high in early phases and then decreasing over time beginning at the conceptualization stage/phase. However, respondents may look at the construction process instead of taking into consideration the safety impact. Although the goal of this study is to focus on safety opportunities, the researchers did not attempt to influence the responses to prevent any assumed bias. The second most common choice amongst the respondents is the design phase (64% of respondents). The percent of responses decreases with each subsequent phase in the project timeline as the construction phase, and operations and maintenance phase were selected by 45% and 30% of the respondents, respectively.

The survey discloses that using BIM may help with the project delivery method, and choosing whether to use the technology is impacted by the delivery method itself. Regarding the project delivery method that their firms use traditionally with projects that adopt BIM, the engineers stated that design-build is the most commonly used delivery method (52% of respondents). Design-bid-build and CM-at-risk were the second choices, each with 42% of the respondents, while other methods received a 30% response rate. In fact, this result is consistent with the literature that states that the design-build delivery method is the most frequently used delivery method for complex projects [29]. Design-build and the traditional design-bid-build method comprise a greater share of the construction contracting methods used in practice. Moreover, 72% of the respondents think that the choice of which technology to use on a project is affected by the delivery method. This result requires further research to show why a specific project delivery method is preferred over others with regard to using BIM.

4.3. Analysis Using Econometric Modelling

To better understand the factors discussed above that have a statistical impact in determining if BIM improves safety, an econometric modelling technique was applied utilizing the survey results. Responses from the management personnel were used to shed light on the factors that lead to construction personnel thinking that BIM increases safety. In doing so, the binary logistic regression modeling framework was utilized due to having only two possible outcomes—1 if BIM increases safety and 0 otherwise. This modeling framework has been utilized and presented in transportation safety literature [30–33], yet applying this econometric technique with regard to construction safety is scarce. With that in mind, to determine the probability that the outcome takes the value 1 (e.g., BIM increases safety), the following binary logit form applies [34]:

$$P_S = \frac{e^{\tilde{\beta}}}{1 + e^{\tilde{\beta}}}, \text{ where } \tilde{\beta} = \beta_0 + \beta_1 X_1 + \dots + \beta_k X_k \quad (1)$$

where P_S is the probability that construction personnel believe BIM increases safety, β are the estimated parameters and X are the explanatory variables used to determine the outcome probability. For this analysis, the estimated parameters are simply the coefficient outputs, $\tilde{\beta}$, provided by the modeling framework. The explanatory variables used for this analysis are variables selected based on the responses from the survey. For example, workers who have 5 to 10 years of experience in the construction industry are used as an explanatory variable to determine if workers with such experience believe that BIM improves safety.

Upon fitting several models, the best fit binary logit model was obtained based on the statistical significance of each variable. Each explanatory variable accounted for at least 10% of the total observations and descriptive statistics of significant variables are shown in Table 1. Furthermore, best fit model specifications are presented in Table 2.

Table 1. Descriptive statistics and descriptions of significant variables.

Variable	Mean	Standard Deviation
Experience in Construction Industry (1 if 5 to 10 Years, 0 Otherwise)	0.245	0.434
BIM Ease Communication Among Project Parties (1 if Yes, 0 Otherwise)	0.653	0.481
Project Delivery Method Affect Which Technology is Used (1 if Yes, 0 Otherwise)	0.796	0.407
Job Title (1 if Project Manager, 0 Otherwise)	0.286	0.456
Age (1 if Less Than 30 Years, 0 Otherwise)	0.367	0.487
Projects	0.388	0.492

Table 2. Best fit binary logit model specifications.

Variable	Coefficient	t-statistic	Partial Effect	t-statistic
Constant	−2.27	−2.03	-	-
Experience in Construction Industry (1 if 5 to 10 Years, 0 Otherwise)	2.59	2.19	0.39	3.09
BIM Eases Communication Among Project Parties (1 if Yes, 0 Otherwise)	1.56	1.83	0.25	1.99
Project Delivery Method Affects Which Technology is Used (1 if Yes, 0 Otherwise)	1.99	1.91	0.31	2.19
Job Title (1 if Project Manager, 0 Otherwise)	−2.65	−2.46	−0.38	−3.41
Age (1 if Less Than 30 Years, 0 Otherwise)	−1.84	−1.82	−0.27	−2.21
Projects	1.55	1.51	0.23	1.74
Log-Likelihood at Zero	−33.92	-	-	-
Log-Likelihood at Convergence	−20.88	-	-	-
McFadden Pseudo-R ²	0.38	-	-	-

Partial effects (a one unit increase in that explanatory variable while holding all others constant) show that having 5 to 10 years of experience in the construction industry has the largest effect on an engineer's perspective regarding whether BIM improves safety. Partial effects indicate that engineers with 5 to 10 years of experience have a 0.39 higher probability of thinking BIM improves safety. Engineers with 5 to 10 years of experience may have more exposure to BIM which could be why they have an increased probability of thinking BIM improves safety. With regard to whether the project delivery method affects the technology that is used, partial effects show a 0.31 higher probability that engineers will perceive that BIM improves safety if the engineers believe that the project delivery method impacts the technology choice. Further, partial effects suggest that workers who believe BIM eases communication among project parties have a 0.25 higher probability of perceiving that BIM improves safety.

On the other hand, two factors lead to a decrease in the probability of an engineer thinking BIM improves safety. For example, partial effects show that being a project manager results in a 0.38 lower probability of thinking BIM improves safety. Project managers are likely to have a substantial amount of experience and may have worked several jobs that did not utilize BIM, and therefore may think that BIM does not improve safety. Likewise, partial effects indicate that engineers younger than 30 years of age have a 0.27 lower probability of thinking BIM improves safety. A possible explanation could be that the proportion of workers in the sample younger than 30 years old have not had any exposure to BIM, and hence do not believe that it increases safety.

5. Conclusions

BIM is an innovative solution that introduces different benefits to the construction industry. One benefit that this research is trying to expose is in regard to construction safety. Various studies have been conducted to measure the impact of BIM on the construction industry in general and construction safety in particular, however, these studies did not address all of the related impacts. In addition to being beneficial, this study focusses on drawbacks of using BIM. BIM still has some negative aspects that the industry should focus on to obtain better performance from using BIM. Moreover, this study was conducted to promote the use of BIM in the construction industry to improve safety during a project.

Regarding the benefits that BIM might add, the study suggests that communication is enhanced when using BIM, which also improves safety on job sites. The results show that there are different shortcomings of BIM, such as training and costs required to have the software and a good staff that uses it. Also, a resistant culture in firms has been found to be one of the shortcomings of using BIM. The authors suggest that increasing the general knowledge of this technology and its benefits, as well as including it within university civil engineering curriculums, could overcome this drawback. Unfortunately, these drawbacks are not a direct result from the technology itself, but rather from the work environment. To gauge the different responses of the participants that show there is a direct positive impact of using BIM on construction safety, the authors used the binary logistic regression econometric framework. The statistical analysis of the logit model confirms the direct responses. To increase the validity of future research on the same topic, the authors suggest that the sample size be increased to determine if other factors might impact the perception of safety in regard to BIM.

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Conflicts of Interest: The authors declare no conflict of interest.

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