Building Information Modeling in Architectural Design and Project Delivery: Coordination, Effort Distribution, and Performance Outcomes

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ABSTRACT

Building Information Modeling (BIM) has transformed architectural design and project delivery by replacing discrete documents with a shared, object-based model of the building. This paper examines how BIM influences design coordination, the distribution of design effort across project phases, and measurable delivery outcomes. A conceptual account of BIM as a model-centred process is developed, and its effects are illustrated through a comparison of design effort and key performance indicators between a traditional document-based workflow and a BIM-enabled workflow. The analysis indicates that BIM shifts effort earlier in the project timeline, where the ability to influence cost and performance is greatest and the cost of changes is lowest, while reducing requests for information, design clashes, and rework during construction. The discussion considers the organisational and contractual conditions required to realise these benefits, including collaborative procurement and clearly defined model uses. The study concludes that BIM delivers value primarily as a coordinated process rather than as a modelling tool in isolation.

KEYWORDS: *Building Information Modeling, Architectural design, Project delivery, Design coordination, Clash detection, Effort distribution, Construction performance*

INTRODUCTION

Building Information Modeling has reshaped the practice of architecture and construction by representing a building as a structured, object-based model rather than a set of independent drawings (1). This shift enables information to be shared, analysed, and coordinated across disciplines throughout the project life cycle (3).

The reported benefits of BIM include improved coordination, fewer errors, and better-informed decisions, although adoption has been uneven and is shaped by organisational and contractual factors (2). A recurring observation is that BIM redistributes design effort, requiring greater investment in the early stages of a project in exchange for reduced effort and risk later (4).

This paper examines the influence of BIM on design coordination, the distribution of effort across project phases, and delivery outcomes (6). By comparing a traditional workflow with a BIM-enabled workflow, it seeks to clarify both the nature of the benefits and the conditions under which they are achieved (8).

LITERATURE REVIEW

Research on BIM spans definitions and frameworks, empirical evaluations of benefits, and studies of adoption barriers. Conceptual work has positioned BIM as a process and a set of policies as much as a technology, distinguishing modelling, collaboration, and integration maturity levels (3). Empirical studies have reported reductions in errors, requests for information, and rework, alongside improvements in schedule and cost certainty (4).

Reported Benefits and Adoption Barriers

The literature identifies a consistent set of benefits and a corresponding set of barriers to adoption:

- Improved multidisciplinary coordination and early clash detection (4).
- Reduced requests for information and rework during construction (2).
- Better support for analysis, visualisation, and decision-making (6).
- Barriers including training needs, software cost, and contractual fragmentation (6).

Studies of existing buildings further note that capturing as-built conditions for BIM remains challenging, which affects the use of the technology in renovation and facility management (5).

RESEARCH GAP

Although the benefits of BIM are widely reported, accounts that connect the redistribution of design effort to specific delivery outcomes within a single comparative frame are less common. The relationship between earlier effort, improved coordination, and reduced construction-stage problems is often described qualitatively rather than examined together. This paper addresses that gap by considering effort distribution and performance indicators jointly.

OBJECTIVES

- To articulate BIM as a model-centred, coordinated process across the project life cycle.
- To compare the distribution of design effort between traditional and BIM-enabled workflows.
- To evaluate key performance indicators including clashes, requests for information, and rework.
- To identify the organisational and contractual conditions required to realise BIM benefits.

METHODOLOGY

The study adopted a comparative approach in which a representative building project was considered under two delivery workflows (8). The traditional workflow relied on discipline-specific documents coordinated manually, while the BIM-enabled workflow used a shared model with defined uses and coordination procedures (7).

Workflow Definition and Model Uses

The model uses assigned to the BIM-enabled workflow and the corresponding level of development are summarised in Table 1. Uses ranged from design authoring and coordination to quantity extraction and construction sequencing (7). Defining these uses explicitly allowed the contribution of BIM to be related to specific project tasks rather than treated in the abstract (3).

Table 1: BIM uses and level of development in the enabled workflow

BIM use	Project phase	Level of development
Design authoring	Schematic to design development	LOD 200-300

BIM use	Project phase	Level of development
Clash detection and coordination	Design development	LOD 300
Quantity take-off	Documentation	LOD 300-350
Construction sequencing	Construction	LOD 350
As-built and handover	Operation	LOD 500

Performance Indicators and Comparison

Both workflows were assessed against a common set of performance indicators, including the number of design clashes identified before construction, requests for information during construction, change orders, and rework cost (4). The distribution of design effort across project phases was also characterised to capture the front-loading associated with BIM (2). The indicators were chosen to reflect both coordination quality and delivery outcomes.

RESULTS AND FINDINGS

The redistribution of design effort and the relationship between project phase, influence over cost, and the cost of changes are illustrated in Figure 1. The figure contrasts the effort profile of the traditional and BIM-enabled workflows against the well-known decline in the ability to influence cost as a project advances.

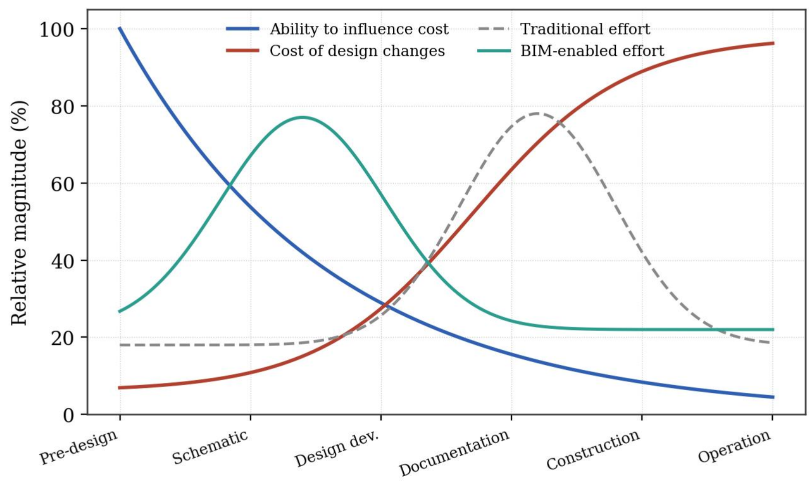

Figure 1: Effort distribution and cost-influence relationship across project phases

The BIM-enabled workflow concentrated effort earlier, during schematic and design-development phases, where the ability to influence cost is high and the cost of changes is low. The traditional workflow, by contrast, peaked later, when changes are more disruptive and costly. The associated performance outcomes are summarised in Table 2.

Table 2: Performance indicators for the two workflows

Indicator	Traditional	BIM-enabled	Change (%)
Design clashes resolved pre-construction	46	212	+360.9
Requests for information	184	97	-47.3
Change orders	38	21	-44.7
Rework cost (percent of contract)	5.8	2.4	-58.6

DISCUSSION

The comparison supports the view that BIM improves coordination primarily by enabling problems to be identified and resolved before construction begins (4). The large increase in clashes detected and resolved in advance, together with the reduction in requests for information and change orders, indicates that issues were shifted from the construction stage, where they are costly, to the design stage, where they are cheaper to address (2).

This pattern is consistent with the redistribution of effort shown in the effort profile. By front-loading work into phases where the ability to influence cost is greatest, BIM aligns the timing of design decisions with their leverage over project outcomes (1). The reduction in rework cost reflects the cumulative effect of better coordination earlier in the process (6).

Realising these benefits, however, depends on conditions beyond the modelling software itself. Collaborative procurement, clearly defined model uses, and adequate training are repeatedly identified as prerequisites, and their absence can prevent the potential of BIM from being achieved (3, 6). The technology is therefore best understood as enabling a coordinated process rather than guaranteeing improved outcomes on its own (8, 9).

CONCLUSION

This paper examined the influence of Building Information Modeling on design coordination, the distribution of design effort, and delivery outcomes. The BIM-enabled workflow concentrated effort in the early phases of the project, increased the resolution of design clashes before construction, and reduced requests for information, change orders, and rework cost relative to a traditional workflow.

The findings indicate that the value of BIM lies in the coordinated process it enables rather than in modelling as an isolated activity. Achieving its benefits requires supportive organisational and contractual arrangements, including collaborative procurement and clearly defined model uses. When these conditions are met, BIM aligns design effort with the phases in which decisions most strongly influence cost and performance.

LIMITATIONS

- The comparison was based on a representative project rather than a large empirical sample.
- Performance indicators were drawn from typical reported ranges and may vary by project type.
- Organisational maturity and team experience were not varied systematically.
- Facility-management benefits over the operational phase were not quantified.

FUTURE SCOPE

- Empirical validation across a portfolio of completed projects.
- Assessment of BIM benefits during the operational and maintenance phases.
- Study of the influence of procurement route on realised outcomes.
- Integration of BIM with emerging analysis and automation tools.

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