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CROSSING COMMUNICATION BOUNDARY WITH VIRTUAL REPRESENTATIONS: A BIM CASE STUDY

TREO Paper

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Abstract

Virtual representations are pivotal in facilitating cross-boundary communication among stakeholders in complex collaborations such as construction projects. Building Information Models (BIM)—process-based virtual representations often function as boundary objects that enable information exchange and construct shared understanding within and between project teams. While previous research recognizes drawbacks of digital models as boundary objects—such as their inherent complexity and limited interpretive flexibility, our research reveals the surprising versatility of BIM in different types of cross-boundary communications. In this study, we draw on semiotic theory, analyzing team members' uses of BIM in various communication practices, examining BIM's capabilities to signify referent objects, meanings, and processes during communication. We found that BIM models are used flexibly in cross-boundary communications as polyvalent signs with multiple semiotic properties, including iconicity, symbolism, and indexicality. This endows them with the affordances to function as effective boundary objects that offer communicative value beyond simple digital objects.

Keywords: Virtual Representation, Boundary Objects, Semiotics, Building Information Modeling.

1 Introduction

Digital artifacts are increasingly used to simulate physical objects, with a growing focus on constructing digital twins and metaverses, especially in the construction industry. BIM (Building Information Models) play a crucial role as facilitators in these virtual environments, aiding in sensemaking and planning (Boland et al., 2007; Comi & Whyte, 2018). These digital models are complex, requiring integrated processes and shared understandings to function effectively as boundary objects that enable information exchange and knowledge creation within project teams (Leonardi et al., 2019; Papadonikolaki et al., 2019; Miettinen & Paavola, 2018). Despite the potential of digital collaboration, the introduction of new technologies can complicate rather than simplify communication, sometimes reducing interpretative flexibility among diverse team members (Neff et al., 2010). This research explores the following research question: How do the semiotic properties of virtual representations, serve as boundary objects to facilitate cross-boundary communication in inter-disciplinary and multi-organizational projects? For this purpose, we conducted a case study on BIM-based collaboration in large, multi-team construction projects. Applying semiotic theory to conceptualize the BIM models, our research reveals a pluralistic view of these virtual representations as boundary objects. We found that the roles of BIM models vary across different types of communication, going beyond their traditional function as tools for shared understanding and communication efficiency.

2 Virtual Representation, Boundary Object, and Semiotics in Communication

Virtuality occurs when digital representations substitute for physical objects, processes, or people. As detailed by Carlile (2002), these representations are digital forms of objects, processes, or systems that

enhance understanding and communication. They range from simple 2D diagrams to intricate, multidimensional models and act as shared referential bases in collaborative endeavors, effectively mediating communication boundaries. Communication boundaries, shaped by mediated communication theories, represent obstacles in communicative activities that block shared understanding's development and conveyance. Digital models can function as boundary objects, a concept introduced by Star and Griesemer (1989), facilitating interaction across communication barriers by providing a joint point that adapts to diverse group needs and perspectives. The significance of digital models as boundary objects in communication, particularly in multidisciplinary team collaborations, has been emphasized (Leonardi et al., 2019; Papadonikolaki et al., 2019), with Building Information Models (BIM) exemplifying such a virtual representation. BIM models extend beyond a mere 3D model to a comprehensive system containing information vital to various stakeholders, promoting multi-organizational collaboration by offering a shared, adaptable space for information/knowledge exchange.

Virtual representations of digital models mediate communication by acting as signs, a concept rooted in traditional semiotics. This theory suggests that signs, through different mechanisms of signification—indices, icons, and symbols (Peirce, 1932, cited by Bailey et al., 2012)—play a crucial role in communication. Indices are signs with a direct physical connection to their referents, facilitating understanding through a demonstrative logic of operational consequences. Icons, based on resemblance, offer immediate recognizability across diverse audiences, simplifying complex ideas through visual similarity. Symbols, relying on convention or learned associations, require a social context for interpretation, often representing abstract concepts or meanings. This framework allows for an analysis of the communicative affordances of virtual representations, shedding light on how they function within the realm of digital technology-enabled communication.

3 Preliminary Findings and Expected Contributions

Our study explores digital representation in commercial construction projects in China, which employs BIM (Building Information Modelling) as a core technology. By examining projects in Beijing and Chengdu, we aimed to unravel the role of BIM technologies throughout its lifecycle in facilitating communication among various project teams. Using an embedded multiple case study design (Yin, 2009), we selected projects managed by organizations with BIM experience, ensuring an investigation of experienced practitioners and setting a benchmark for BIM implementation. Our study examines three construction projects and five organizations (focusing on a general contractor, a design institution, a BIM consultancy, a sub-construction organization, and a project owner), illustrating diverse uses of BIM technology across contractual parties and project phases. It highlights the dual-phase lifecycle of a typical BIM-based project, encompassing design and construction, underscoring their interdependence and feedback loops. Our primary data comprise 27 in-depth semi-structured interviews, offering insights from various team roles. Supplemental data were gathered through on-site observations, participation in BIM-related project meetings, and analysis of project documents, such as blueprints, BIM models, and construction standards, to provide a comprehensive view of BIM practices.

Adopting a practice lens, we focus our analysis on the repeated and situated interactions with particular technologies in communication activities in the community of the construction project (Braun & Clarke, 2022). Our findings reveal different semiotic natures of BIM models in daily communication among construction project teams. The following is a very brief demonstration of our findings.

- **BIM model as an icon** – crossing disciplinary boundary: during the project, the 3D model is frequently used to 'visualize' a technical problem. Our data illustrates how the BIM model in this instance serves as an iconic representation, through providing an immediate and intuitive vision of the problem at hand, affords demonstrative and explanatory communication between technical roles from different disciplines to enable trans-disciplinary problem-solving.
- **BIM technology as a symbol** – crossing organizational boundaries: technicians working in the general construction team often make deliberate references to the BIM model in their communication with clients. In this instance, BIM is often referred to as an 'cutting-edge technology' or a 'scientific method', which in its appearance embodies the advanced, systematic

approach to construction. By symbolizing a shared goal of value creation embedded in the multi-organizational project, BIM thus can afford negotiatory interactions, in constructors' attempt in aligning with client stakeholders across organizational boundaries.

- **BIM simulation as index** – crossing operational boundary: when different operational components (e.g., architectural design, structural design, piping design) are integrated into the BIM model, a simulation is run to visualize conflicts and problems. Upon sharing the simulated model, technicians from different design teams propose operational solutions by making suggestions for changes to the model. This indicates the indexical nature of BIM simulation – when exposing the causal relationship between the future-projecting model and an infeasible operational process, it indexes processual incompatibility in operating teams. BIM's affordances here become apparent in facilitating coordinated action and orchestrating communication across operational boundaries.

Our research aims to contribute first from a literature synthesis that extends semiotics to communication practices. This leads to suggest that virtual representations, such as BIM, have multiple semiotic properties that facilitate meaning transfer across disciplinary and organizational boundaries. Through analyzing how BIM's communicative affordances arise from the interplay between its material aspects and the social dynamics of goal-oriented users, we contribute to the literature of boundary objects by revealing how BIM's iconic, symbolic, and indexical nature in communication mediation impact cross-boundary collaborations. This study also contributes to the understanding of virtual representations by extending their pluralistic semiotic characteristics in mediating cross-boundary communication.

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