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The Factors Affecting Collaborative Building Design

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Abstract

Collaboration is an important requisite in the multi-participant building design environment. The performance of a building as an end product is enabled via the collaborative efforts of project participants. The main objective of this paper is to identify the factors that affect the collaboration among the participants in the building design process. The related data is collected from the growing literature on collaborative design. Recent technological developments that serve a higher level of collaboration and the construction industry's efforts to improve building performance are also considered. A conceptual model is proposed to address the collaborative relationship between the participants of the building design process. The challenge is to enable collaboration by integrating the work performed by participants with diverse backgrounds, varying levels of expertise, and different perspectives. The implication of this research is that a good understanding of the factors that enhance collaboration between the parties involved in design not only enhances building performance, but also improves the competitiveness of building design firms.

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Keywords: collaborative design; design phase participants; construction industry;

1. Introduction

Building design is a comprehensive work performed by diverse participants cooperating in a multi-disciplinary environment [15]. The requisites for strong collaboration include having common goals and sharing responsibility, authority, and accountability among collaborators. The main objective of collaboration is to achieve a satisfactory end

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result that involves more than the sum of the knowledge of all individuals working on the product. The project-based environment of the construction industry requires that individual design professionals work in a collaborative environment. The goal of design professionals is to produce a building that performs well. Design teams composed of individual professionals working toward this common goal need maximum collaboration among participants. The main objective of this research is to identify the factors that affect the collaboration among the participants in the building design process. Collaborative design that uses a Building Information Modelling (BIM) technology platform promises to provide an effective means of designing and communicating through networking and real-time data sharing [17]. Therefore, emerging technologies such as BIM will be taken into consideration in this study.

The following section describes a review of the literature on collaborative practices and presents a conceptual model that maps the core components of collaboration to the work of professionals in building design. The next section shares the results of an extensive review of literature on collaboration and building design. The last section describes the factors that affect collaboration among building design professionals and discusses of future research opportunities in this field.

2. Literature Review

Collaboration has differing definitions and names (working together, joint venture, working jointly with others, joining forces, working in partnership, pooling resources, acting as a team, cooperating with one another, etc.) that vary slightly from each other, but the general meaning involves more than one entity working together toward a shared goal. Collaboration was studied by many researchers such as Kabler and Genshaft [13], Moriarty [16], Smith et al., [21], Tuckman [23], Tuckman and Jensen, [24], Buckley and Casson [7], Todeva and Knoke [22], Ash [1], DelPizzo [8], Kysiak [14], Rockefeller [19], Grubbs [11], and Gajda [10]. The relevant parts of these studies are presented in the following subsections.

2.1. The context of collaboration in building design

The design phase of building projects is highly interdisciplinary, involving contributions from architects, structural engineers, mechanical engineers, electrical engineers, environmental scientists, etc. Many professionals from varying fields work together to design a building. Therefore, the design activity needs a high level of integration of different professions. Because building design is achieved by teamwork, individual design professionals should collectively work for a common goal. The need to integrate the activities of different design professionals requires that the key factors that affect collaboration are identified and a conceptual model for measuring collaboration in building design is developed.

The key features of a design process that supports and encourages integration and proper co-ordination between the various participants of a building project, are the virtual company, emphasis on front end, design fixity, teamwork, communication, single contact point, change management, process management, process and project legacy archive, and soft and hard gates [20].

2.2. Project Design Participants

The design of building projects is realized by professionals with diverse backgrounds, various expertise, and different perspectives of creativity. The participants in the design process are the contractor, the project management team (in the traditional project delivery system (design-bid-build), which is most common, these two entities are never involved in design), the client, the design team, consultants, and government authorities. If they want to work together as a team, these participants have to develop relationships to collect and analyse the design related data to refine and coordinate the data and to develop the final design. The relationships among design participants are shaped according to the state of need for knowledge. Therefore, the collaboration among design phase participants is highly knowledge intensive. Knowledge shared between two participants is directly related to the participants' work focus.

2.3. Existing collaboration models

Since collaboration is important for integration, many scholars studied the subject and proposed models such as the Peterson Model [18], the Levels of Community Linkage Model [12], the Bailey and Koney Model [3], the Levels of Integration Model [10], and Five Stage Model. These models mostly focus on stages of collaboration. The theories of stages describe levels of collaboration, where the lowest level represents little or no collaboration and the highest level represents intense collaboration or, ultimately, complete unification. The models vary from each other on the number of stages, the levels included, and the definitions of stages. Gajda [10] argued that passing to higher stages, groups become more effective. The model is described below.

The five levels of collaboration are developed based on the work of Hogue [12] and Borden and Perkins [5, 6]. Existing or expected collaborative relationships in the five stages are defined. The five levels of collaboration are set as networking, cooperation, coordination, coalition, and collaboration. Each level has its own purpose, characteristics, leadership, decision-making, and interpersonal strategy. Peterson's [18] and Hogue's [12] collaboration model was extended by Bailey and Koney [3] to include coadunation as the highest level of integration, which involves complete relinquishment of autonomy for strengthening a surviving entity. The five-level collaboration model suggested by Hogue [12] was adapted in this study. The model is described below.

2.4. Key influence factors

There are challenges of program complexity, phasing parameters, legal restrictions, engineering options, interior design alternatives, and landscape/site limitations while providing lead-lag time for an integrated building design solution, but construction project is held in a multi-participant and multi-disciplinary working environment. There may be additional problems that occur in an environment in which work is carried out by inter-professional collaboration. Beaulieu's [4] research on inter-professional collaboration found that organizations confront particular barriers in inter-professional collaboration in project-focused teams. According to Austin [2] these barriers include organizational mechanisms, coordination for design, coordination of communication, determined and clear processes and procedures, work organization and resources, professional area, experience in the relevant project type, workloads, organizational policies, supportive organizational culture, project-based approach, and trust and healthy inter-personal connections.

3. Methodology

The research involved constructing a measurement scale for collaborative design metrics by performing a review of the published collaboration literature and the participants of the design phase were determined and organized in manageable groups. A conceptual model was developed to represent the design process, the participant groups, and the knowledge shared during the process. The factors affecting collaborative design in building design were identified. Participant groups and collaboration levels will be integrated in the next research paper. The five-stage model of levels of community linkage suggested by Hogue [12] was selected, using the "no interaction" situation as the baseline. In developing the measurement scale, the participant groups, their interactions, the level of collaboration and the building design process were examined in detail.

4. Results and Discussions

Collaborative design is established through the participating disciplines' mutual understanding of technical, aesthetic, and social aspects of a building project. One way to keep a collaborative design manageable is to define three groups of participants: core design team members, strategic supporters, and decision supporters. Participant groups are determined by considering their span of effect on the design of the project. The groups represented in concentric circles in Figure.1 reflect the ascendant span of power on design-related decisions. The centre of power in design decision-making is the "core design team" that includes architects, structural engineers, landscape designers, interior designers, electrical engineers, mechanical engineers, environmental specialists, and construction professionals. The core design team is broken into three groups, namely: 1st order designers (architects), 2nd order designers (structural engineers, landscape designers, interior designers), and 3rd order designers (electrical engineers, mechanical engineers, and environmental engineers). The core design team is responsible for the building design and high-level decision-making in the design process. The second group includes "strategic supporters" that includes project management, the client, and the contractor. This group maintains the knowledge and other resources for the use of the core design team. Strategic supporters are those project participants who can make decisions on specific themes or issues within their responsibility and whose ideas and knowledge are involved in the design activities. Finally, the last group is "decision supporters" that includes consultants, and public authorities.

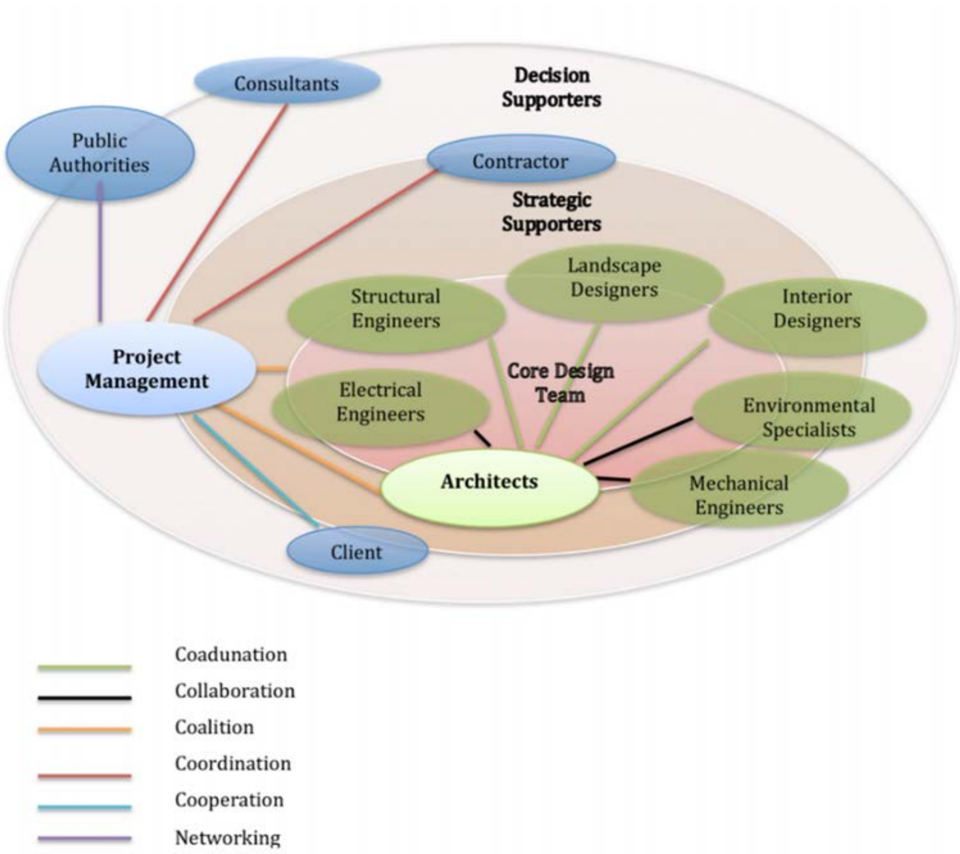

Fig. 1. Conceptual model of collaborative design among building design phase participants.

These participants only provide consultancy and information for the related project, respectively. Decision supporters are not permanent members of the project consortium but collaborate at specific stage or on a temporary basis in the project. The network of participants can be visualized in a consortium network diagram that represents the collaboration among building design participants. The collaborative design map of building design is presented in Fig. 2. The steps of the design process, the related participants and the knowledge that is shared among participants are shown in this figure. The inputs as a baseline for design phase and output as a guide for construction phase of the project are pictured. According to the information stated above about the building design process, its participants, and participants' interactions, the key factors that affect the extent of collaboration in building design can be categorized in five main strategic measurement groups, namely; 'individual-level factors', 'project-related factors', 'organizational-level factors', 'BIM implementation factors', and 'physical factors' as listed in Tab. 1.

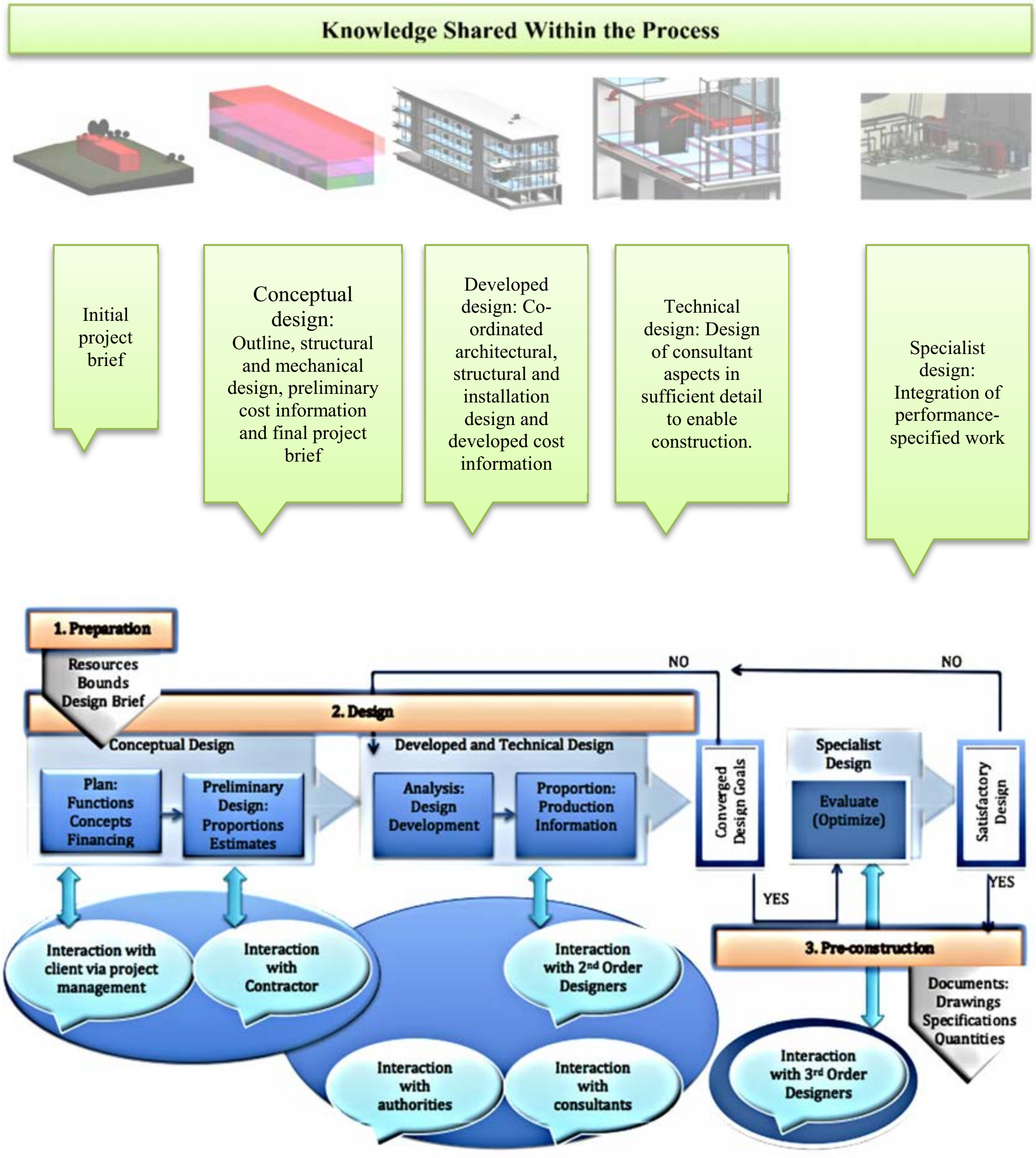

Fig. 2. Collaborative design map of integrated building design phase.

In addition to individual factors such as technical skills and openness to share, project-related factors are considered since construction projects are held in a project-based environment. Organizational-level factors that affect intra-organization and inter-organization collaboration are also considered at the corporate level.

BIM is an information technology that provides, virtual prototyping, simulation, distributed access, retrieval and update of building information [9, 15], and is acknowledged as an integration tool for participants.

As such, the application of BIM in collaborative design has BIM receives a separate heading in defining collaborative design metrics for building design. Finally, physical factors that represent the conditions related to information technology, infrastructure, are also considered in the model.

Table 1. Collaborative design metrics for building design.

Relevance to Participant Groups	Design Phase / Relevant Levels of Collaboration	Measurement Group	Factors
Core Design Team	Preparation / No-existence Concept Design / Networking Developed and Technical Design / Coordination Pre-construction / Cooperation	Individual-level Factors	Technical skills Openness to share Engagement in each other's work Openness to communication Establish personal relationships
Core Design Team + Strategic Support	Preparation / Cooperation Concept Design / Cooperation Developed and Technical Design / Coordination Pre-construction / Cooperation	Project-level Factors	Agree on the project scope Agree on design process with ground rules for working together Design a RAM/RACI Matrix for effective communication and determined responsibility areas Naturally emerged leadership for effective meetings Concrete, attainable goals and objectives Shared vision Members Share Linked efforts Collective decision making process Flexibility Adaptability Sufficient funds Active contribution Skilled convener
Strategic Support	Preparation / Cooperation Concept Design / Cooperation Developed and Technical Design / Coordination Pre-construction / Cooperation	Organizational-level Factors	Defined organizational structure Determine meeting guidelines Define rules Determine the power (budget control) holder/s Promote collaboration Outspread of power (flat organization) Open communication channels Multiple layers of decision-making Clearly defined roles and responsibilities and policy guidelines Adaptability and flexibility in organization structure and in work processes Technological readiness Fluid knowledge sharing system
		Physical Factors	Integrated environment Accessible knowledge Collaborative workspaces to enhance collective working, design decision making and team participation
Core Design Team + Decision Support + Strategic Support	Preparation / Networking Concept Design / Cooperation Developed and Technical Design / Coalition Pre-construction / Coalition	BIM implementation Factors	Availability of BIM technology Build technological infrastructure for collaboration Cyber security in data sharing

5. Conclusions

The research investigates collaboration in building design. The design phase is examined through the design participants, the knowledge shared during the design process, and the collaboration level among participants. Collaborative design metrics for building design are constructed after an extensive literature review on related subjects. The study is limited to developing a model of measurement metrics. Factor analysis can be performed after data are collected by administering a survey to building design participants, hence verifying the proposed measurement model.

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