

CONFERENCE PAPER

NZAAR-BDC-16-12 BDC 2016

Staging the Collaborative Design Process: The Potential Catalyst for BIM-Based Design Studio

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PUBLISHED IN

The Second NZAAR International Event Series on Natural and Built Environment, Cities, Sustainability and Advanced Engineering
International Conference on BIM, Digital Fabrication and Computational Simulation/Visualization (BDC 2016)

Pages	81-91 of the volume
Held	8 December 2016, GTower Hotel, Kuala Lumpur, Malaysia
ISSN	2463-5979 (online) 2463-5960 (print)
Publisher	New Zealand Academy of Applied Research Ltd, Auckland

ABSTRACT

Designing is a major activity that supports the introduction, development and implementation of products, services, practices, and systems. Contemporarily, the collaborative approach to designing is considered more efficient than the conventional silo design practice. However, the collaborative design approach tends to be underresearched. Therefore, this research investigates on identifying key components of collaboration as they unfold in the architectural design studio through, student-tutor design interaction in the conventional studio environment. Fifteen (15) weeks of student-tutor design interaction was followed, during which seven students present their designs to the tutor for consultation on a weekly basis. The verbal communication that unfolds between the students and tutor was the data used for the study. After careful study of the data, the study identified the key components of collaboration within the design studio environment, which includes problem framing (issues, scene, difference, and clashes), information searching, idea generation, communication and knowledge transfer. The study recommends possible supports for the identified components in staging the collaborative design studio as expound by the Building Information Modeling (BIM) concepts. To this end, this study has proposed a staging for the collaborative design process which will serve as a potential catalyst for the BIM-based design studio. Future studies can explore on the identified components for possible empirical and methodological research.

Keywords: Design; Collaboration; Studio; Building Information Modelling

HOW TO CITE

Danfulani Babangida Idi and Khairul Anwar Mohamed Khaidzir (2016). Staging the Collaborative Design Process: The Potential Catalyst for BIM-Based Design Studio. In *The Second NZAAR International Event Series on Natural and Built Environment, Cities, Sustainability and Advanced Engineering*, Kuala Lumpur, Malaysia, 8 December 2016 (pp. 81-91). Auckland: New Zealand Academy of Applied Research. ISSN 2463-5979 (online), 2463-5960 (print).

STAGING THE COLLABORATIVE DESIGN PROCESS: THE POTENTIAL CATALYST FOR BIM-BASED DESIGN STUDIO

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Abstract

Designing is a major activity that supports the introduction, development and implementation of products, services, practices, and systems. Contemporarily, the collaborative approach to designing is considered more efficient than the conventional silo design practice. However, the collaborative design approach tends to be under-researched. Therefore, this research investigates on identifying key components of collaboration as they unfold in the architectural design studio through, student-tutor design interaction in the conventional studio environment. Fifteen (15) weeks of student-tutor design interaction was followed, during which seven students present their designs to the tutor for consultation on a weekly basis. The verbal communication that unfolds between the students and tutor was the data used for the study. After careful study of the data, the study identified the key components of collaboration within the design studio environment, which includes problem framing (issues, scene, difference, and clashes), information searching, idea generation, communication and knowledge transfer. The study recommends possible supports for the identified components in staging the collaborative design studio as expound by the Building Information Modeling (BIM) concepts. To this end, this study has proposed a staging for the collaborative design process which will serve as a potential catalyst for the BIM-based design studio. Future studies can explore on the identified components for possible empirical and methodological research.

Keywords: Design, Collaboration, Studio, Building Information Modelling.

1. Introduction

Collaboration is considered a vital instrument for the successful implementation of complex activities. It potentially serves as an effective ecosystem for knowledge and information sharing, thus facilitating better coordination and increased understanding among the major stakeholders in the main industries like building and construction. The collaborative process can be view as an effective instrument for dealing with complex problems encountered particularly in building design and construction activities. In reality, issues pertaining collaboration are not easy to contend due to the many challenges at hand. Among them is the participation of multiple layers of stakeholders who would bring in a plethora of perspectives, problem parameters and constraints to project implementation. Furthermore, these stakeholders imbue highly differentiated (time) types and levels

of intervention to projects as well the vast array skills, strategies, tactics and methods that come with it. Thus, collaboration most likely necessitates certain changes and adaptation to organizational and project operations about values, requirements, and needs. It could encourage increased innovation to the ways stakeholders practice and perform towards success. Some may advocate complete changes to systems to accommodate effective collaborative processes. Despite these assertions, we are yet to comprehend fully the inner workings of good collaborative activities. What would be good parameters of Collaboration? For quite some time, the construction industry has vigorously promoted collaboration as the way forward to remedy the notorious profligacy of the sector. The promotion of BIM framework and application as a vital platform for collaboration highlights the importance of acquiring congruent and interoperable

information and knowledge transactions between frontline stakeholders. However, this study tries to explore another important view of collaboration ‘interaction’ among design stakeholders. The interaction represents the communication of design information in a collaborative design environment focus on design education. The aim of the study is to explore and enhance collaborative design practice as the potential catalyst for BIM-based design education.

2. Literature Review

Currently, the design process is an independent problem-solving practice, unidisciplinary, knowledge, expertise, problem-solving, training and behavior [1-15]. Even though the detailed design is a joint work but, each stakeholder presents interdependent solutions [16-20]. In a move to encourage the improvement of team design practice Valkenburg and Dorst [21] compared two teams of four students each using protocol analysis. The study established that design characteristics such as naming, framing, moving and reflection have a different pattern of behavior in team design. Chiu [22] established that collaboration is more productive and structured in design practice than design education. In a similar study on collaboration in design Dong [23] found that stakeholders’ language similarities provide productive mental idea sharing among team members. Communication in design can be simplified using some intelligent support systems according to Erkert et al. [24] while, Sonnenwald [25] suggest communication as one of the informant factors for multidisciplinary collaboration. Goldschmidt [26] established that there are almost no differences between individual and collaborative designing. However, other studies [27-36] employed the used of design techniques, tools, strategies and cognitive activities to reveal an effective difference of collaborative design. However, this research intends to look at another dimension of the role of

collaboration in design practice [37-40]. Literature has indicated that technologies of distributed and organizational teamwork will continue to dominate design and construction disciplines [41-43]. Their ability to integrate stakeholders from different disciplines and geographical location working synchronously together are some of the factors that are influencing the dominance. Contemporary design and construction practice will immensely depend on this concept in future. Therefore, these necessitate to a call for a collaborative design platform that can facilitate this process. However, the issue of properly upgrading the conventional design practices is a significant research gap. Hence, this study proposed to investigate the role and effect of collaboration in collaborative design and finally, to develop a model that will contribute to enhancing the concept.

2.1 Collaborative Design

The collaboration is defined as the working together of individuals, group/s or organization/s to achieve define common goal. Individual collaboration is an interaction between individuals, while group collaborations is an interaction between more group and finally, the organizational collaboration is the highest level of interaction which is to companies, institutions, states, countries, and disciplines [44-48],[26]. Collaboration could either be synchronously or asynchronously [49]. Synchronous collaboration the interaction is a real-time and same time such as face to face brainstorming, chatting, video conferencing, apprenticeship, discussion, dialogue, sharing presentation and information. Asynchronous collaboration is a time-shifted interaction; that is different time and location e.g. email messages, audio, and video streaming. Collaboration among other aspects facilitates effective decision making, feedback, ideation, knowledge sharing, discovery, and development. The collaboration was an efficient tool for design and construction

teamwork. Through which layers of information are share, create, integrate, adopt and implement. In a similar vein, contemporary research studies are agitating for a collaborative design ecosystem for product design, construction, operation, and maintenance. This request explores collaboration to be a prominent research component for design, construction and information communication technology (ICT) domains [50-53]. The collaborative ecosystem may require effective planning and managerial provision for it effective setup, implementation, and operation. Some of the issues that may require proper planning are managing stakeholders activities such as knowledge sharing, ideation, clashes and information communication that arose due to clustering of stakeholder working in the same ecosystem and target a single design goal. Furthermore, issues related to collaborative design ecosystem is an area that is equally in need of further studies and clarification. As a result, this study carries out a research observation to identify the role of collaborative design, similarly to determine the effect of collaboration factors in the collaborative design and finally, to develop a collaborative design model for the enhancement of collaborative design⁵⁴⁻⁵⁸. Based on literature studies issues pertaining cost, speed, accuracy, clash detection, and operability are among major solution provided by collaborative design (Table 1). It remains the same the ecosystem for the integration of the collaborative design is not readily available but, it is among the major areas of this study. Some of the objectives of the study include to identify the role of collaboration in design, to determine the factors of collaborative design and finally to develop a collaborative design model. In conventional design and construction practice little is known about the collaborative design and it working ecosystem where stakeholders work multidisciplinary toward a target outcome. The collaborative design model can provide some initial steps for proper

communication, knowledge sharing, iterations and problem-solving for effective project delivery. This research intends to study collaborative design in design education focusing on issues related stakeholders interaction. Some literature has indicated useful advantages of collaboration that relates to speed, error reduction and accuracy in organizational and distributed workings. However, issues related to difficulties that might transcribe from matters relating to managing stakeholders interaction in collaborative design are among issued addressed in this study.

Table 1. Characteristics of Collaborative design: a review perspective

	Characteristics	Literature Studies
Collaborative Design	Observation Interview Brainstorming	Gross ⁵⁹ ; Goel ¹¹ ; Lawson ^{60,1,4} ; Dorst ¹⁰ ; Goldsmidt ²⁶ ; Dubberly and Evenson ⁶¹ ; Danfulani and Anwar ⁶² .
	Text Verbal Metaphor	Goel ^{12,11} ; Danfulani and Anwar ⁶³ ; Stones and Cassidy ⁶⁴ ; Uluoglu ⁶⁵ .
	Prototyping Framing Layering	Danfulani and Anwar ⁶² ; Salmana ⁶⁶ ; Goel ¹² ; Lawson ^{60,1,4} ; Dorst ¹⁰ .
	Modelling Simulation Operations	Macdonald ⁶⁷ ; Gabriel and Maher ³² ; Chung et al. ⁶⁸ ; Dave and Koskela ⁶⁹ ; Faraj et al. ⁷⁰ ; Girlo and Jardim-Goncalves ⁵⁰ ; Gross et al. ⁷¹ ; Gu et al. ³¹ ; Han et al. ⁷² ; Wang and Dunston ⁷³ ; Chiu and Lan ⁷⁴ ; Lee et al. ⁷⁵ .

3. Research Methods

Literature has indicated design problem-solving as a process of phases of events and activities moving from one step to the other with the development, structuring, refinement and detailing of target artefact [13,1,6,11,9,10]. Among methods of studying design, activities are protocol studies. Protocol studies are the most prominent method of studying design process using protocol analysis observation, and interview [80,81]. Eastman [82] conducted the first protocol study in 1968 in which experienced architectural designers were asked to redesign the interior of a residential bathroom [83]. The study involved stages from experimental design,

subject recruitment, conducting experiments, transcribing protocols, coding schemes, quantitative and qualitative comparisons and the final result outcome. Protocol studies could be content oriented and process oriented. The content-oriented approach is the study of the drawings produced, such as sketch, CAD drawings, and models. The process-oriented approach is the study of the process of production such as behaviors, verbal use, and gestures. These is evident from studies carried out by Goel [11] to examine if there are important differences between the cognitive processes involved in design problem-solving tasks, such as architectural, engineering, and non-design such as playing chess or making a medical diagnosis. A total of 16 protocols, twelve (12) from design situations (architecture and engineering) and four (4) from non-design situations (chess playing and medical diagnosis). More recently protocol studies were also used to compare two design working environments, manual pencil and paper and the monitor, keyboard, mouse working conditions, using FBS, Chi-square Test, and Paired –T test. Protocol study was chosen as the research methodology for this study because of its ability to study design activities using behavior, verbalization, and gestures. The methods used for this research is observation. The study involves a design studio space where designers work collaboratively with a design tutor. The research subjects are seven (7) final year undergraduate architectural design students and a tutor working on a design course in a studio environment, the researcher is the only observer in the studio all from Architecture Department, Universiti Teknologi Malaysia. The students are working on their final thesis project; they are required to identify a research problem and find architectural solutions to the identified problem. The studio mentor who is an experienced academician and tutor is working collaborative to guide the students throughout the fifteen (15) weeks stipulated time for the thesis period. During this

period, students met with their supervisor weekly as well as attending panel presentation at certain intervals. Students work are assessed and graded during this presentations using a grading scale provided by the faculty. The data collection process includes all weekly, and specific panel presentations. During which the research data was established. Finally, the study employed qualitative research method using video observation investigate and offer possible properties of knowledge sharing as a variable of collaborative design.

4. Analysis & Results

The study employs qualitative research method of analyzes data from direct fieldwork observations of design studio activities, using designers behavior, verbal, visual and textual design information communication as the medium of the analysis. In some circumstances interviews, and analyzing written documents were also carried out. Qualitative research analysis further engages in analyzing the setting of the studio environment to generate rich narrative descriptions and construct a proper understanding of the concept. Inductive analysis across many cases in the design process yields patterns and themes of collaboration in the design session which is the fruit of the qualitative research study. The research data obtained from retrospective observation of the studio activities, necessary subject interview, were also carried out. The observed data revealed some unique features of knowledge sharing in the design process. The identified features occurred during the conceptual process of analyzing and generation, product information communication and detailing, and finally, new tacit knowledge development through testing, modeling, and operation. The analysis has also established collaboration as a modality of knowledge sharing. Therefore, it understanding will contribute to efficient design information sharing among stakeholders in the design process. It was

also understood that, in design sharing, and peering of knowledge and information among stakeholders are all facilitated through collaboration. The analysis also indicates that one of the significant aspects of collaboration in design is knowledge sharing. Therefore, effective collaborative skill will assist in molding designer with effective knowledge sharing skills.

This study has found collaboration as the mechanization of the design process which translates into a knowledge sharing system. Also, this study has also found that design process involves integration and transformation process of information searching, information identification, information structuring and finally information implementation. This study further established that the interaction between tacit and tacit knowledge in design determines designers' level of experience and the availability of information on the client, user, site, environmental, climatic and atmospheric information. These imply that designer collaboration with team members, users, and the environment is of paramount importance. These support the notion that design is also a knowledge sharing process. According to [61] design process could also be a knowledge sharing the process. Thus, this study could add up to the notion that collaboration facilitates knowledge sharing in a controlled studio environment. Collaboration could term as the modality that links design and knowledge sharing, through an interview, brainstorming, verbalization, sketching, framing, layering, modeling, and operation. The knowledge sharing process includes the interaction between tacit and explicit (Figure 1). It can conclude that there exist a link between design and knowledge sharing. It became even clear through examining the effect of collaboration on the two processes. This study has been able to connect knowledge sharing and design process. The study has been able to address theoretically the hypothesis that design is a knowledge creation process. The study

further used collaboration as a modality to explore the link further through observation of collaborative design between student designers' and a tutor. Other findings also suggest that design facilitates knowledge transformation from the tacit to explicit domains of knowledge, however, future studies can still justify the suggestion. Based on the understanding of collaborative design so far, this study developed a four-stage model of collaborative design. The model also includes the method of sharing explicit and tacit knowledge in the design process. Also, the model provides some understanding of how to plan the operation of the collaborative design. The four stages of the model represent the collaborative design process. Further studies can develop, refine and expand the model where necessary. The concept of provided by the building information modeling BIM-based collaboration is a multidisciplinary collaboration concept that enhanced and simplified teamwork. Future studies can provide adequate research whether the BIM-based collaboration can provide disambiguating simplification of design as a knowledge sharing the process. It concludes that collaboration is a catalyst for design as knowledge sharing. Therefore, any improvement in design collaboration can result in the achievement of a better outcome and knowledge creation and gain.

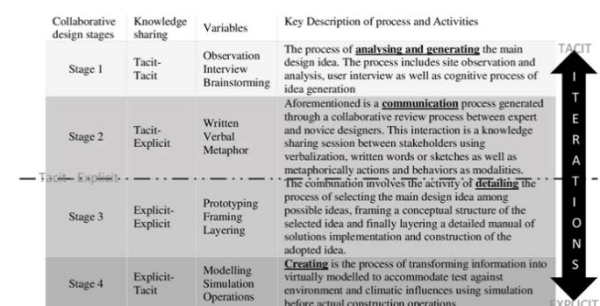


Figure 1. The four stages Collaborative design Model

4.1 Stage 1

The example of stage one includes a brainstorming session that facilitates the understanding of the design requirement, investigation of different design context and

cognitive process of innovation. By observing design requirement such as sociocultural influence, economic and environmental influences through designer – user interaction, visual and retrospective observation of user activities as well as generating mental ideas through brainstorming (Figure 1) of possible design solutions.

4.2 Stage 2

Stage 2 are factors that influence the progressive transformation of initial design concepts. Designers communicate, validate, transform and assess their design through a certain medium of Textual, Verbal, and Metaphorical methods are some of the common methods of design externalization. Through which expert and visionary designers challenge competent, and novice designers design with criticism such as disapproval, faultiness, correctness or mistakes. Through this criticism expert and visionary designers' analysis competent and novice designers' design and make judgments', improvements and meaningful contribution to the design. Stage 2 clarify ambiguous design discoveries are clarified in design presentations and meeting through written or prescribe feedback, verbal or oral feedback as well as metaphorical actions and descriptive behavioral feedback.

4.3 Stage 3

Initial design ideas are abstract spatial depictive. However, Stage 3 is transformational process successfully transform and communicate design idea from abstract to concrete spatially specific artifacts. The Stage 3 process includes prototyping, framing, and layering of the artifact. Prototyping is the process of using exemplary existing product or artifacts to compare merit and demerit with the proposed design. Framing is the process of outlining proposal, zoning, diagramming and planning of the proposed design. The framing represents the actual preliminary structure of the design. Finally, layering represents the arrangements, distribution

and documentation of different phases of the design in the form of plans, sections, elevations, site plans and perspective views.

4.4 Stage 4

Stage 4 is the process of developing, testing or implementing designed product or artifact. In this stage, the schematized design transforms in a concrete form either to carry out a test or actual design adoption. Stage 4 includes the information driven from virtual building models. Model of product or artifact give some sense of views, construction processes, clash detection and cost analysis. Designs undergo simulation as to analyze and test either atmospheric conditions, energy efficiency, solar radiation, day lighting or other design requirements.

5. Discussion & Conclusion

Literature has not provided substantial evidence the operation of the collaborative design. However, in this study knowledge, sharing has been identified as a modality that can describe the operation of the collaborative design. Being an interactive process, through knowledge sharing activities such as observation, interview, and brainstorming between individuals and groups collaborative design is carried out. According to [79] knowledge sharing can be facilitated through verbalization, written script, behavior, and actions. During studio presentation, stakeholders make uses these modalities of collaboration in design. Sometimes it may extend to the use of documented referencing or exploration of ideas using sketches and metaphorical description in the form of action, signs, behavior, and gestures. Student designers collaborate with experienced tutors to share, identify, develop and create knowledge embedded in the design process and product developed. They also used the opportunity provide by the collaboration to develop their tacit knowledge that accumulation will transform to another level of expertise. The explication of tacit knowledge is an advanced level of

knowledge development that assist in producing an effective understanding of mental ideas, misunderstanding, and clarification of the ambiguous situation. This study uses protocol studies¹¹ to understand the characteristics of collaborative designs^{79,61} in the design process. The analysis indicates that collaboration between designers has externalized the relationship between knowledge sharing and design. In the socialization context of the knowledge sharing, students collaborate with a tutor during design conceptualization through observation, interview, and brainstorming. The collaboration is normally a studio interaction where issues about constraints, requirement and bylaws are discussed and scrutinized. During this period, designers' knowledge coordinated and shared. This coordinating process will end in revealing the actual discovery of the new design concept.

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