

Sharing Tacit Design Knowledge in a Distributed Design Environment

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ABSTRACT

This paper reports a case study that was conducted to observe the exchange of tacit design knowledge in a distributed design environment. Prototype software was developed and tested in a undergraduate design studio in which design students sought advice from experts in remote locations. It provides tools for showing images, such as drawings, renderings, and for engaging in a written dialogue (chat session). Data were collected and analyzed using both qualitative and quantitative methods to enhance the validity of findings--through content analysis, log files, simple statistics, and questionnaires.

1. INTRODUCTION

Throughout the life-cycle of a design project, architects rely heavily on their tacit design knowledge to support design decisions. Tacit knowledge is highly personal, unstructured and implicit (Polanyi 1966). As such, it encompasses expertise, intuitive understanding, and professional insight formed as a result of experience. Due to its implicit nature, tacit design knowledge is typically shared only among colleagues who work in the same office through face-to-face interactions. With emerging CMC (Computer-Mediated Communication) technologies, designers face new opportunities for capturing and reusing tacit design knowledge. However, there is no accepted CMC strategy for sharing tacit design knowledge in the AEC industry.

This research investigates the impact of tacit design knowledge on design performance in a distributed design environment supported by CMC software. The software was developed and tested in three design studios in which design students sought advice from experts in remote locations. It provides tools for showing images, such as drawings, renderings, and for engaging in a written dialogue (chat session). The written and graphic artifacts of the conversation are stored in a Web-accessible database.

The chat sessions included the identification, clarification and explanation of real problems. Dialogue records provide evidence of a significant influence upon the students' approach to conceptual design. Content analysis of the comments from the experts provides qualitative evidence for the software's effectiveness. The participants shared past experience, professional recommendations and intuitive expectations. In follow-up surveys, most participants reported that their experience with the software was very enjoyable and the software is well-designed to support sharing of design knowledge.

This research also suggests that tacit design knowledge may be confidently captured and shared through careful strategic implementation in a distributed design environment. Demographic and attitudinal surveys of the participants suggest that enabling factors for sharing tacit design knowledge include knowledge sharing attitude, just-in-time expertise matching, and timing of the communication.

2. METHODS

Instrumental case study approach has been selected as the most suitable method of inquiry. A design problem was given to a group of participants, architectural design students, and they were requested to produce a design solution to meet the requirements of the design problem. Data were collected and analyzed using both qualitative and quantitative methods to enhance the validity of findings--through content analysis, log files, simple statistics, and questionnaires. Quantitative data such as questionnaire results, log files and counts of frequencies of software use supplement qualitative observational data to triangulate evidence, producing more valid conclusions.

3. SETTINGS

The case study was conducted in an undergraduate level design studio at Texas A&M University, College Station, TX, during 2004. The design studio undertook a design project for the historic downtown of the City of Bryan. The course objective was to generate architectural proposals in responding to the historical architectural context.

The studio instructor encouraged the students to use the software as a substitute of a weekly design critique. Because this design studio was conducted in a summer semester, the class met every weekday. Consequently, Friday is often very tired and stressful for the students. The instructor wanted the students to be more excited about the opportunity to talk with design professionals, such as architects, city staffs, and engineers. The instructor asked students to discuss with the design critics about their own design projects. The design critics and students never had a face-to-face meeting.

A plot in the historic downtown was assigned to the students to be developed as a small commercial shop with the residential functionality. The new building should be kept within the range of 4500 sq. ft. The shop could be designed according to a unique theme, such as a coffee shop, a pub, a bookstore, a casual wear shop, or a sport articles shop. The students were asked to explore the possibilities of linking residential and working activities, but at the same time they want to be able to keep certain residential autonomy. The design of the residential area should incorporate features characterizing the profession of the owners. The residential area is composed of two two-bedroom units for rent. At the time of the experiment, the theme had been already decided and the students were in the conceptual design phase.

4. PARTICIPANTS

The participants for this case study were twelve undergraduate students completing the third year of a four-year Environmental Design program from Texas A&M University. Of these initial participants, seven students participated in real-time chat sessions while other five students just logged in at the chat sessions. The students who participated in the chat sessions completed the post-test questionnaire. None of the participants do have previous work experience as a designer or engineer in the industry. The participants' average age was 20 years. They have similar backgrounds but they have different attitude about knowledge acquisition and CMC technology. The researcher did not participate in the chat sessions except to answer technical questions and to help use the software.

The twelve students were divided into three groups. Since the project is located in historic downtown of the City of Bryan, the instructor was very careful to select guest critics with a great deal of previous experience in this area. One local architect and one city staff person were selected as design critics. Due to the difficulties of finding local design critics, one architect from Venezuela was selected as a design critic. He has in-depth knowledge on the design theories and space manipulation.

5. PROCEDURES

Before the chat session, the students upload a PDF version of their conceptual drawings and model pictures to display them in the chat session. They also asked to fill out a pre-experiment questionnaire. The design critics were asked to look at the design artifacts before the chat session. After conducting a one-hour training session, a 4 hour chat session was conducted in a strictly controlled computer lab environment. The students logged into the system at the same time and spent the same amount of time in the system. The chat session was conducted in a computer lab equipped with Pentium IV computers with high-speed Internet connection. A digital projector was used to demonstrate the software. Then, they communicated in a chat room to discuss the design projects. At the end of the semester, the students submitted and displayed final posters at a gallery area in the College of Architecture. Those posters have been recorded to observe the difference after the chat session. The author sent an email that asked to fill out the post-experiment questionnaire.

6. FINDINGS

6.1 Qualitative analysis

Student 1

This case illustrates reuse of tacit knowledge during the chat session. Student 1 is a 21 years old female student majoring in Environmental Design program. She conducted a 10 minutes online chat with a local architect who is one of founding Principal in a local architectural design firm. The critic's primary expertise is architectural design and visualization technologies. Since he has conducted numerous projects in the City of Bryan, he was able to give valuable suggestions about the site condition and the city regulation.

Within her project a small international coffee shop sits next to and beneath a bronze foundry and residential loft. The coffee shop specializes in gourmet coffee from around the world and also offers a selection of pastries and desserts. The presentation of the coffees is kept in the tradition of the country and culture from which it came. The intention is that this unique atmosphere allows for the customer to experience a distinct cultural flavor yet feel as though they are part of a larger cultural diffusion.

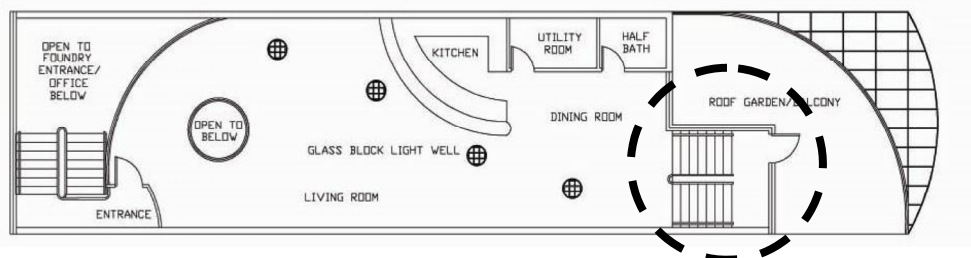
When they started their conversation, the design critic asked student 1 whether she read his comments to another student as follows:

Critic 1: "Did you read my comments to Barrett about the access issues?"

Student 1: "Yes, I had originally had a lift for wheelchairs at the entrance on the empty space to the right."

As indicated in the excerpt above, the design critic wanted to give her the same comments about the wheelchair accessibility at public spaces. All students who have the same problem were able to fix their design artifacts according to the critic's comments. She also revised her drawings at the end of the semester as shown in Fig. 1.

Before



After

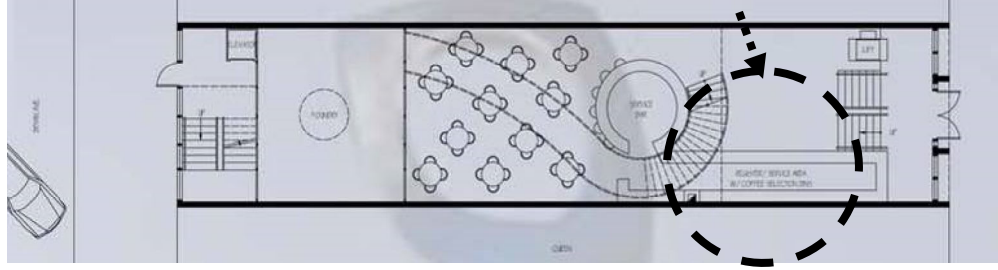


Figure 1 Student Example 1

Student 2

Student 2 is a 22 year-old female student majoring Environmental Design program. Her design critic is an architect working in Venezuela who received a Master of Architecture at University of California, Berkeley. He is very familiar with design theories concepts. Because he never visited the city of Bryan before, he could not give the comments about the local context of the project. The majority of the comments from him are about the design concepts, form, and theories.

Her project is a French bakery attached to a loft home where the family that lives there and operated family-owned business. She wanted to create the same atmosphere for the guests as well. Since the family resides on the top of the bakery, she wanted create an interaction between the two spaces. The wood fire oven is the central feature which is used by both the bakery and the family. The curved form of the elements has been emphasized to create a soft and comfortable environment. The facade also reflects the curves that are happening inside the space. The left side is glass wall so that people can see the oven from outside and invite guests. Her conceptual model was made of paper and green-color form to emphasize the main idea of this project which is a wooden bakery oven (See Fig. 3).

They spent approximately fifteen minutes on reviewing her design concepts. The critic was able to rapidly conceive a problem for her project and quickly made comments to achieve more comprehensive design solution. At first, her idea was really impressive and the design critic was very impressed. However, when he looked at her drawings (See Fig. 2), he made a following comment:

Critic 2: "when I see you model I see a strong idea, but when I see your drawings that strong idea almost vanishes."

Student 2: "Well, the oven is definitely the main feature of my building."

Critic 2: "The fireplace and the oven, both can be recognized from the inside as special elements and it serves as function and entertainment value."

Critic 2: "CELEBRATE the elements!"

Student 2 produced a revised section which reflected the suggestions from the critics, as show in Fig. 4.

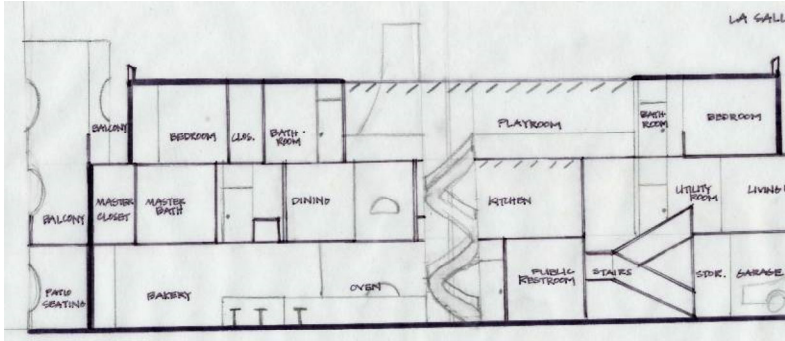


Figure 2 Section (before the chat session)

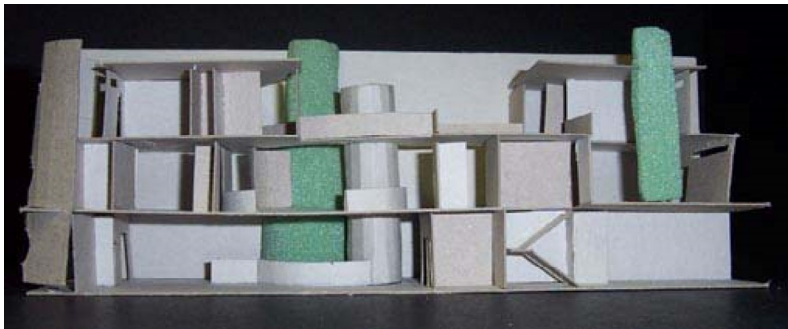


Figure 3 Model picture (before the chat session)

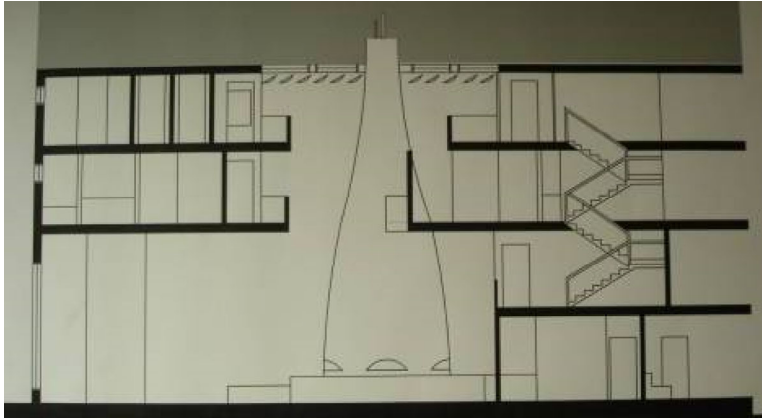


Figure 4 Revised section (after the chat session)

6.1 Quantitative Analysis

The students varied in their perceptions of the integration of CMC technologies in design studios. The questions about CMC technology perceptions were asked twice in both questionnaires. Figure 5 shows the difference in the perception of CMC technology before and after the experiment. The perception of phone, groupware, virtual directory, and email stay the same. However, their perception about chat/instant messaging and video conferencing was greatly improved as shown in Figure 5. The results suggest further that students recognize chat/instant messaging as an opportunity to share tacit design knowledge and interact with others, not as a communication medium in which they only strive for facilitating faster communication.

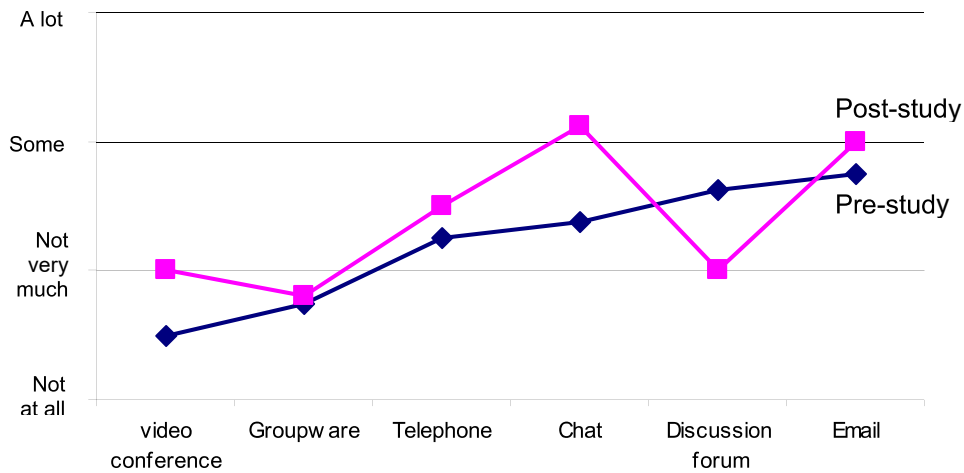


Fig. 5 Student perceptions on CMC

7. THEORETICAL MODEL DEVELOPMENT

A theoretical model for design knowledge sharing process has been developed by formulating the research results (See Fig. 6). Design knowledge sharing is initiated by applying 'generalized tacit design knowledge' to a specific design problem. When the students talked with their design critiques to acquire tacit design knowledge, the design critic's generalized tacit design knowledge may become 'specific tacit design knowledge' with the consideration of a specific design problem.

The students then convert specific tacit design knowledge into explicit formats, such as sketches, models, and drawings. Although those explicit expressions are often inadequate to fully articulate tacit design knowledge, it is a typical process of reflective practice in the design profession (Schon 1983). And then, the students produce a design solution and update 'generalized explicit design knowledge'. Finally, what they experience are converted and accumulated as 'generalized tacit design knowledge' in the form of shared mental model or technical know-how (Nonaka and Tacheuchi 1995).

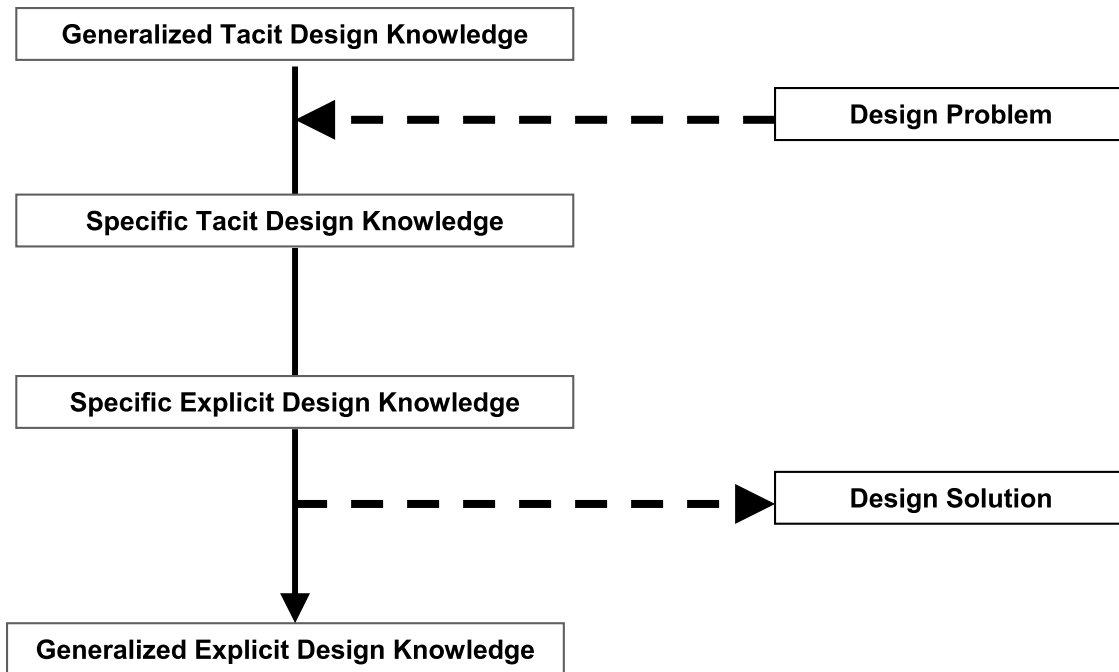


Fig. 6 Theoretical Model Development

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