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Abstract

This paper introduces three case studies that implement the idea of Computer-Mediated Communication (CMC) strategies to share and reuse tacit design knowledge in a distributed design environment. Prototype 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 and 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. This study also suggests that tacit design knowledge may be confidently captured and shared through careful strategic implementation of CMC technology in a distributed design environment.

Overview

This paper introduces three case studies that implement the idea of Computer-Mediated Communication (CMC) strategies to share and reuse tacit design knowledge in a distributed design environment. A review of literatures led to a theoretical framework for the exchange of tacit design knowledge in a distributed design environment. A software prototype was devised to operationalize the use of CMC. Three case studies were conducted using the software to validate the theoretical framework and gain insight into what occurs when design instructors purposely use CMC technologies to help architecture students attain specific instructional objectives. The case studies then provided evidence that tacit design knowledge can be shared and reused by using chat-based CMC strategies.

Theories of Tacit Knowledge

Tacit knowledge is the intangible form of human knowledge. Michael Polanyi is the first person who began to draw a distinction between explicit and tacit knowledge. Polanyi describes tacit knowledge as “very personal knowledge” constructed in a social context. He also asserts that tacit knowledge cannot be expressed in explicit languages as he says “We can know more than we can tell.”

Nonaka and Takeuchi recognized the importance of tacit knowledge and tried to demonstrate how to transfer personal tacit knowledge to shared mental models and technical skills. Their theoretical model is adopted as the foundation for the theoretical development for this research.
Current Knowledge Management in the AEC Industry

The AEC (Architecture, Engineering and Construction) industry has been successful at collecting and storing explicit information databases as represented in design manuals and handbooks, such as *Architectural Graphic Standards* or *Timesaver Standards*. Various types of web-based project management tools are also offering explicit knowledge management solutions. However, the industry may be poor at tacit knowledge retrieval and sharing. Fruchter and Demian\(^3\) said that this strategy often failed because of the following factors: overhead required to capture; limited knowledge; poor IT infrastructure of organizations.

Sharing Tacit Design Knowledge with CMC technologies

Some researchers in the field of architecture have rigorously studied the importance of sharing tacit design knowledge sharing. Various terminologies for tacit knowledge have been adopted: visual analogy\(^1\), episodic knowledge\(^9\), reflective practice\(^8\), personal knowledge\(^2\), expert knowledge\(^1\), and strategic knowledge\(^5\).

Due to the development of emerging CMC technologies and geographically dispersed business environments, the use of CMC has been inevitably accepted. Face-to-face meeting is now being recognized as too costly in terms of time and expense. CMC research has focused on the potential of various synchronous and asynchronous collaboration technologies to improve work performance\(^4\). The technologies include voice recognition, online conferencing, instant messaging, chat, blogging, and email.

Synchronous chat has been a CMC technology for interaction with entertaining purposes. It is beginning to be used in the work place. In the field of architecture, Kvan and Candy\(^5\) studied and argued that synchronous chat plays a significant role in the solution of collaborative design problems. Clearly, there is widespread curiosity regarding how to use CMC to facilitate tacit knowledge exchange in the AEC industry.

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![Knowledge Spiral Diagram](image-url)
Throughout the literature review, a recurring theme emerged substantially was the importance of tacit knowledge sharing in a collaborative work environment. A series of design research and CMC theory literature recognizes the challenges and potential of tacit design knowledge in a distributed design environment. However, little research has been conducted investigating how CMC helps the architectural design process. Previous studies could not clearly identify the impact of tacit design knowledge on design performance in a distributed design environment.

**Methods**

The general methods used in the studies were consistent throughout all three case studies: content analysis and questionnaires. 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 and 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 profiles of the cases are summarized in Table 1.

In all cases, a design problem was given to a group of participants, usually architectural design students, and they were asked to produce a design solution that meets the requirements of the design problem. Students consulted with experts as needed and desired. The second case employed graduate students and the first and third cases employed undergraduate students.

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Table 1 Profiles of the three cases

**Findings**

**Findings from qualitative analysis**

Although the chat sessions are unstructured and informal, the students were pleased to receive immediate tacit help from design critics. A significant portion of the online chats was devoted to the identification, clarification or explanation of real problems. The majority of the problems were identified by the design critics in the chat sessions. The students did easily catch problems,
and then revised their projects to solve those problems. The following three examples show how the students applied shared tacit design knowledge to their design projects.

The first example explains how the design critics identified the design problems from the student project. The critic was a local architect who is a principal in an architectural design firm. The critic’s primary expertise lies in architectural design and visualization technology. Since he has conducted numerous projects in the same area, he was able to give valuable suggestions about the site conditions and city regulations.

Their chat sessions were very informal and short, but also concise and straightforward. As shown in Figure 2, the design critic pointed out inappropriate design elements on the front elevation. The project site is a part of a historic district where keeps old structures which are listed on the National Register of Historical Places. The critic suggested considering the existing design of the proposed building. During the final design stage, the student changed the front elevation to be harmonious with the surrounding area (See Figure 3).

![Figure 2 Revised building elevation drawing](image1)

**Figure 2 Revised building elevation drawing**

![Figure 3 Building elevation drawing within its original context](image2)

**Figure 3 Building elevation drawing within its original context**

The second example shows how easily the students receive technical help through the chat sessions. One design critic representing the local chapter of USGBC (United States of Green Building Council) was particularly knowledgeable about sustainable design. He suggested
composite (wood and recycled plastic) decking rather than hardwood decking to incorporate the concepts of sustainable architecture. This student was immediately able to ask a few questions about the composite decking option and agreed to use it. Figure 4 shows his revised drawing that was produced at the end of the semester.

![Revised building section drawing](image)

The following dialogue indicates how the design critics’ comments influenced a premature design idea to be a realistic one. One of the questions that the students encountered was the possibility of using a vest as a body restraint in zero-gravity environment. During online chat, NASA staff was able to provide helpful comments for developing “upper body restraint system.” Based on these comments, a student developed a proposal to offer “multi retracting units” as shown at Figure 5. His proposed system can be used to allow standing posture. Triangulation of the restraint belts creates maximum stability and tension that creates pressure on the lower body.

**Conversations**

- Reviewer: The decking is an opportunity for the composites - wood and recycled plastic.
- Reviewer: Trex, Choice-Dek, etc.
- Student 3: do they have the same visual quality as hard wood?
- Reviewer: Exterior wood is a maintenance nightmare
- Reviewer: The composite decking looks very different
- Student 3: that is one thing i want to avoid... maintenance costs
- Reviewer: If you go with wood, consider fastening the deck boards from below. There are various methods these days. I know this is very detail oriented, and you are trying to design the whole building.
- Student 3: probably i will change from hard wood to composite.

**Before**

**After**

Figure 4 Revised building section drawing

The following dialogue indicates how the design critics’ comments influenced on a premature design idea to be a realistic one. One of the questions that the students encountered was the possibility of using a vest as a body restraint in zero-gravity environment. During online chat, NASA staff was able to provide helpful comments for developing “upper body restraint system.” Based on these comments, a student developed a proposal to offer “multi retracting units” as shown at Figure 5. His proposed system can be used to allow standing posture. Triangulation of the restraint belts creates maximum stability and tension that creates pressure on the lower body.

- **<Student 1>** What about a vest that would be put on when long duration restraint was necessary?
- **<NASA 1>** Upper Body Restraint system - Vest may be an option, consider that it may need to be pretty tight to restraint crewmembers and it may still move (oscillate) due to other attachments.
Findings from quantitative analysis
A post-experiment questionnaire was given to 19 students participated in the second and third case studies. The students reported their perception on the use of the software by answering questions. The students’ perception indicated that the chat sessions are very helpful in improving their design projects. They would consider using the software for sharing design knowledge in their next design studio. Written comments indicated that students also expressed clear expectations that synchronous chat could be improved with more dynamic visual display, such as “mark-up systems.” Figure 6 shows a comparison of the students’ perception on the use of the software: overall satisfaction on the chat sessions, functionality of the software, overall satisfaction on the software, usefulness in design improvement, and satisfaction with the chat archives.

![Chart showing students' perception on software usage](chart.png)

Figure 6 Students’ perception on the use of the software from the second and third cases
Conclusion

The above examples reveal that the chat sessions help in sharing professional suggestions, identifying real problems, and providing technical help. The analysis of chat transcripts and design artifacts also reveals that the software assist in capturing and sharing experts’ tacit knowledge. The students who share tacit knowledge through online conversations apply the knowledge to their design artifacts.

Many researchers have undertaken studies concerning the potential of CMC technologies to support architectural design processes in a distributed design environment. However, their research has rarely explored how experts’ knowledge affects student design performance. The contribution of this paper lies in recognizing the significance of the tacit design knowledge contained in design communications (chat sessions) in a distributed design environment.

The chat sessions included the identification, clarification, and explanation of real problems. The critics’ comments formed the most concrete solutions of the problem. Furthermore, the participants shared professional recommendations, and intuitive expectations. 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. Because of this, a method for capturing knowledge should be developed in the future. When professionals handle knowledge of high value, they intuitively want to capture it, but often they cannot spend adequate time to capture and store it appropriately.

Reference


