

Student response to an Internet-mediated industrial design studio course

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Abstract The purpose of this study is to investigate student attitudes towards and perceptions of using the Internet and information technology to mediate a design studio course and to propose guidelines and suggestions for developing Internet-mediated design studio courses. Two classes of third-year undergraduate industrial design students in two collaborating universities in Taiwan—Chang Gung University and National Yunlin University of Science and Technology—participated in an experimental design studio course mediated with an online design learning environment. Surveys and focus group interviews were conducted at the end of the course to record students' attitudes and perceptions. The students thought that the approach used had a positive influence on design teaching and learning and expressed acceptance of using the Internet to support design education. Finally, suggestions were proposed to help design educators in adopting, modifying, and developing systems for using the Internet to mediate design studio courses.

Keywords Design education · Design students · Design studio · Industrial design · Internet · Online design learning environment

Introduction

With the rapid development of the Internet and of information technology (IT) and the globalization of business and product development, design practices have changed. The

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most notable change has been the use of digital design assistance tools (e.g., computer-aided design (CAD) and computer-aided manufacturing (CAM)) and their application to support design communication and information transmission. In the face of these rapid changes in the design environment, the education of students to be familiar with these new methods and techniques has become a critical issue for design education.

Many educators and researchers have tried to use the Internet and IT in various design projects. In e-learning studies, the learner has always been considered to be the center of the study system. Therefore, his/her initiative and view of the Internet have been very important factors for system designers (Gillani 2003). Furthermore, in this study, the attitudes and perceptions of students taking part in an Internet-mediated design studio course have provided useful information to help design educators adopt, modify, and develop such systems in the future.

This study is part of a research project to explore the feasibility of adopting online design learning environments (ODLE) in industrial design education. The purpose of this study is to investigate students' attitudes towards and perceptions of using the Internet and IT to mediate a design studio course, with the intention of proposing guidelines and suggestions for developing such courses.

Assessing the impact of technological revolutions is difficult, but it is nonetheless necessary to venture an assessment of accomplishments and an informed view of emerging opportunities in need of further development (Kalay 2006). In a single study, though, it is difficult to describe the whole spectrum influences that an Internet-mediated design course exerts on learning. This paper simply focuses on the students' perceptions to provide one piece of the puzzle.

Design education and the Internet

Design has its own particularities of knowledge which need to be considered when using the Internet and IT to mediate a design studio course. This section will discuss design education, the potential of the Internet and IT in the field of design education, and the problems encountered when using the Internet and IT in a design studio course.

Design and the learning of design

Design is a synthetic discipline; the knowledge required in design covers the realms of both humanities and science (Narvaez 2000). The domain of design is thus very broad. Design is generally considered to involve abductive reasoning, which addresses ill-defined problems and uses a construction process to solve them (Zimring and Craig 2001). Design knowledge must be understood with reference to the problem context. Moreover, design knowledge is not simple information; it cannot be transmitted directly to students in the same way as general content. A design must also be negotiated and discussed with many participants in different programs and subject-matter areas in various domains. Therefore, the design process can be considered as a social process in which the result is constructed using various kinds of knowledge (Bucciarelli 2001).

Learning is the act or process of developing skills or knowledge (Arsham 2002). There exist several perspectives on design learning. Schön (1987) believes that design learning emphasizes working with actual problems to acquire professional knowledge and techniques. As for design education, as Ulusoy (1999) illustrates, it essentially deals with

teaching students how to design, and ideally with guiding students to discover their own ways of designing. Chang and Huang (2002) consider design as a learning process. Learning the process of design is similar to designing. Both activities involve spending a certain period of time thinking through the process and attempting to create interesting results. The main difference between traditional design studios and non-design subjects is that design cannot be regularized as a sequential process of learning patterns. Although there may be some similarity among different design outcomes for the same design project, the processes of achieving them might be totally different. Thus design instruction is usually based on individual experiences. Press and Cooper (2003) have pointed out that “design is a value-driven activity. In creating change, designers impose value upon the world—values of their own or those of their client. To be a designer is a cultural option: designers create culture, create experience and meaning for people. And finally, designers make their own future—this is their most crucial creation. Design education provides possibilities, challenges, skills and understanding, and, with these, they make their lives.” (p. 6)

Design, as an educational subject, is characterized by the absence of a clear demarcation between theoretical knowledge and practical skills. In addition, some design projects require intensive collaboration with numerous specialists. The general instructional strategy in design studios is based on constructivist principles, in which a student actively constructs an internal representation of knowledge by interacting with the material to be learned. The model implements the principles of situated cognition and problem-based learning. According to these theories, both social and physical interactions enter into the definition of a problem and the construction of its solution. Neither the information to be learned nor its symbolic description is specified outside the process of inquiry and the conclusions that emerge from that process (Simoff and Maher 2000).

From a review of the literature, it is clear that design knowledge is difficult to understand or to describe. This knowledge cannot be delivered by the traditional lecture pedagogy, but can be learned by doing, as in the apprentice system. Students need to acquire advanced knowledge through working with design problems in the real world. In the learning process, the teacher demonstrates and leads the students to engage with the real design problem. Students try to observe, to understand, and to grasp the various methods and techniques through the process, to cultivate observation and decision-making capabilities, to explore their own talents, and finally to develop their own procedure and style of design.

The pedagogy of studio-based design education has been in use for almost 100 years (Reimer and Douglas 2003) and is an important teaching method in professional design (Schön 1987), especially in architectural and industrial design. The main distinguishing feature of studio pedagogy is the learning of the procedure and methods of design and the accumulation of experience through the process of solving actual design problems. The emphasis is on the presentation of design concepts and ideas, the critique and communication involved in the design process, and the learning of advanced design knowledge through reflection on design problems. Students go through the procedure of design to solve real or simulated design problems (Attoe and Mugerauer 1991; Budd et al. 1999; Forgber and Russell 1999; Kvan 2001a; Reimer and Douglas 2003). Throughout this hands-on training, they can work in a real design environment. Therefore, design studio education is usually combined with design practice, and the way it is carried out must undoubtedly be adjusted as design practice changes. Those adjustments usually include design topics, methods, and tools.

In the face of the rapid development of technological innovation and globalization, design practice has gradually been moving into a new stage, particularly in the industrial design domain. For instance, a product is often designed by an American or Taiwanese

designer, then manufactured in China or Malaysia, and finally marketed globally. With the trend towards globalization, design practice is coming to feature elements of specialization, delegation, distribution, and cooperation (Haymaker et al. 2000). The tools and communication methods for design practice have therefore changed to include, for example, the use of digital tools and media to assist in concept generation and presentation and the use of the Internet to transmit and communicate design information, all in an effort to practice the concept and methods of knowledge management (Nam 2001). In the face of these changes, design education also needs to change and to incorporate into design teaching the large number of new 2D and 3D CAD tools which have been introduced to assist in design development (Clayton et al. 2002). The Internet and IT have also been used to support design communication and information transmission. In such circumstances, the critical issues for design education are therefore how to address the rapid changes in the design environment and how to educate students to apply these new methods and techniques.

The potential of the Internet for professional design education

The rapid development of the Internet and IT has changed design education. The computer and IT have evolved from subjects of instruction to become tools for learning. Dyson and Campello (2003) believe that new technologies should encourage rethinking of pedagogical aspects of teaching, learning, and assessment. Bender and Vredevoogd (2006) point out that the technology with the greatest potential for impact on design education is the Internet. The Internet has revolutionized the design process by allowing designers to research new products, download specifications, access coded information, transfer drawings, and even collaborate synchronously with colleagues around the world. The Internet provides abundant resources, removes restrictions of time and space, offers great potential for educational applications, and has generated a trend towards using the Internet and IT for both learning and teaching. The Internet and many digital tools are already widely applied in and having an impact on the process and culture of design education (Bender and Vredevoogd 2006; Matthews and Weigand 2001).

The influences of the Internet on design learning arise mainly from removal of the restrictions of time and space, abundant resource availability, and multimedia content. These features offer application and development potential for design education, in particular in the following areas:

- Design resources: the Internet (WWW) provides vast resources, fast information exchange, and many venues for exploring teaching methodology, especially in design-oriented courses (Chang and Huang 2002). Multimedia objects such as photos, drawings, audio recordings, and videos used in the design process can be shared and exchanged through the Internet (Budd et al. 1999; Chastain and Elliott 2000; Cheng 2000). Students can also link with and control distributed resources (Chen et al. 1998) to satisfy the visualization requirements of design.
- Tools and methods: the new design tools and methods based on Internet and information technology, for example, the various computer-aided design and drawing software packages, computer-mediated communications, and resources shared through the Internet, have changed design practice, environment, and methods. These new tools and methods have become additional topics for students to learn (Clayton et al. 2002; McCormick 2004). The new and principal application of these tools and methods is collaborative design. Related tools meet the various functional needs of collaborative

design, making collaboration possible with designers in different geographical locations. Even specialists in other fields and users can participate in collaborative design projects (Budd et al. 1999; Chen et al. 1998; Dave and Danahy 2000; Kolarevic et al. 2000; Wood 2003).

- Interaction and communication: “learning by doing” is the main principle of professional design education. Discussion and criticism involving teachers and peers throughout the design process is the most important activity. The Internet provides a convenient method for extending design discussion and communication outside the studio. Its easy and convenient linking function and abundant resources enable students to share and exchange design documents, collect data, and find design cases for discussion and criticism to increase interaction and develop critical thinking skills (Cheng 2000), as well as helping students to handle complex design problems (Budd et al. 1999). An Internet connection also allows students to collaborate with foreign students to obtain a better understanding of different cultures and design philosophies (Dave and Danahy 2000; Kvan 2001a).
- Learning and presentation: design education is closely related to design practice, and the career of the student will be related to putting knowledge into practice. Therefore, the student must learn new tools and methods to adapt to the new design environment and design methods that have been affected by the Internet and IT (Dave and Danahy 2000; McCormick 2004). Students can improve their ability to integrate social and technical dimensions by means of an Internet-mediated design course (Chen et al. 1998; Cheng 2000). In addition, design students need a space to show their design projects. The traditional method requires a large space and extensive resources to prepare a design show. The number of visitors is also limited by time and space. However, the Internet provides a space that enables students to exhibit their work to a wide and disparate audience (Wood 2003) with low cost and resource requirements.

The Internet offers many advantages and much potential for design education. Since the 1990s, many researchers and educators have tried to use the Internet to mediate or to process design learning projects. Most of these projects were based on the studio pedagogy called the “virtual design studio,” or VDS. The organization and size of a VDS depend on the number of projects, the number of participants, the type of digital media and tools used, and the duration of the project. The purposes and objectives of these VDS can be divided into three categories: (1) campus usage, which provides support to design courses and design information communications (Budd et al. 1999; Craig and Zimring 2000); (2) design collaboration usage, which provides a platform for school-to-school or country-to-country design collaboration, thereby providing an opportunity for students and teachers to work with other students or experts in other environments (Brusasco et al. 2000; Dave and Danahy 2000; Elger and Russell 2003; Kolarevic et al. 2000); and (3) multidisciplinary collaboration which focuses on interdisciplinary design collaboration and provides a platform for integrating students with experts from different fields (Žavbi and Tavčar 2005). According to their degree of use of the Internet (World Wide Web), the Internet-mediated courses can be divided into different levels, from those that provide only basic course information to those that put all course content and course interaction online. Harmon and Jones (1999) suggest that levels of use of the World Wide Web represent a continuum from basic occasional use to the advanced continuous use common in schools, colleges, and corporate training: no Web use, informational Web use, supplemental Web use, essential Web use, communal Web use, and immersive Web use.

The VDS supported by IT and the Internet brings a new challenge to design studio teaching. Using the advantages of IT and the Internet, a greater degree of information sharing, better communication between students and teachers, and the opportunity for students to learn from other experts and peers around the world can be achieved.

Although the Internet and IT offer many advantages, they also pose risks for design education. For example, students may use inappropriate information without thinking or rely excessively on the form-making function provided by digital tools, creating many novel but unreasonable designs.

Problems faced by students in an Internet-mediated design studio

Since the 1990 s, numerous types of virtual design studios have been introduced, but the results and the influences of using the Internet and IT for design education still need to be researched. McCormick (2004) indicated that information and communications technology (ICT) brought many potential benefits to technology education, although evidence of improved performance on traditional tasks was lacking. Using ICT for teaching requires changes to the arrangements for teaching and learning, but teachers might see few implications for what is actually learned. McCormick also mentioned that network technologies offer a new dimension of ICT for tasks such as designing. This dimension might require a transformation in some aspects of technology education.

Research into applying the Internet and IT to design education has focused on the environmental setting (including hardware and software) and, in the early days, on collaborative design and computer-mediated communication. Very little research has been carried out from the point of view of the participants (including students and instructors) to discuss the problems of this pedagogy.

Broadfoot and Bennett (2003) compared traditional face-to-face design studio education with modern Internet-based design studios. After integrating Schön's (1985, 1987) theories with Kvan's (2001a, b) contemporary re-evaluation of design education, Broadfoot and Bennett proposed four conditions for effective contemporary design studio education: (1) learning by doing as a central concept; (2) one-on-one dialogue between teacher and student; (3) a collaborative context for teaching and learning; and (4) process focus. This conclusion can be summarized by saying that design studio education must have certain content and meet certain requirements. Whether using the traditional face-to-face studio or the VDS, Internet and IT applications must satisfy these requirements to achieve the objectives of design education.

Although the VDS and the traditional design studio have the same contexts and objectives, the setting is different. A VDS using the Internet provides unlimited resources, fast information exchange, and many spaces for exploring teaching methodology, especially in design-oriented courses (Chang and Huang 2002). The VDS needs the assistance of the Internet and IT-based tools because it involves the added complexity of exploring and evolving a meaningful methodology with new possibilities for display and communication (Forgber and Russell 1999).

After observing 10 VDS, Yee (2001) concluded that the Internet and IT provide many opportunities and offer great potential for design education, but that these benefits are not easy to achieve. A successful VDS needs good technical support and an enthusiastic response by participants. According to the observed results, the main problems with VDS can be divided into technical and social problems. Technical problems include operating

difficulties and equipment cost. Social problems included individual difficulties, problems in using the studio, and varying levels of instruction.

Žavbi and Tavčar (2005) investigated the opinions and experiences of students after they participated in a virtual product development team project. An open-ended questionnaire was used to collect the students' comments about the technological characteristics and human-interface features of the course. The results indicated that communication was a key problem from both a technological and a human standpoint. Based on their findings, Žavbi and Tavčar proposed that the requirements for effective communication in a virtual product development team must include teamwork and management skills. They also pointed out that future designers need to anticipate the business environment where they will work, which is characterized by constant change and multinational and geographical dispersion. Students and product developers of the future need to be appropriately educated to prepare them to meet the challenge of developing competitive products to ensure their company's long-term success in the market.

Bender and Vredevoogd (2006) believe that studio courses can be enhanced with online technologies. They use a blended learning approach that combines live sessions and online education design courses. Their work demonstrates that blended learning can revolutionize instruction in the design studio. Student learning can be enhanced by having pertinent course material available online whenever students wish to access it. Project critiques can be delivered in both audio and text format and can be reviewed at any time and as many times as needed. All students can view and hear the projects and comments of the entire class, a benefit which is often lacking in a studio environment. Bender and Vredevoogd also point out that, even though the process has been successful for introductory and advanced CAD courses, this approach may not be appropriate for every course because online activities cannot replace hand-drawing and rendering exercises or activities requiring textual artistic media. Pektaş and Erkip (2006) found that success in integrating technology with design education was greatly affected by the attitudes of students toward technology. They investigated the attitudes of design students toward computers, finding that students' attitudes toward the use of computers in design were positive. Their results also revealed that students' attitude towards computer usage in design was closely related to their general attitude towards computers, but was not correlated with their perception of instructors' attitude towards the use of computers in design.

In summary, the problems that students face when using the Internet and IT in a design education program or in a VDS can be divided into two categories, technological and human. Technological problems focus on cost, operation of various tools and equipment, and related knowledge and skills. Human problems include communication, habitual behavior, and cultural issues.

Summary

Because of the unique nature of design knowledge, education for the design profession is different than in other domains. Learners acquire advanced design knowledge through reflection on design problems. Furthermore, design education has an inseparable relationship with design practice. Therefore, design education had to be transformed when design practice was changed by the Internet and IT.

The Internet and information technology offer great potential for design practice and education. Although there are some risks, it is well worth considering how best to apply the Internet and IT to improve professional design education. Many researchers and educators

already use these new technologies to assist in the learning and teaching of design, focusing on the system (the hardware and software environment) and on collaborative issues. From the e-learning point of view, the learners are seen as the center of the learning system, and their motivation is an important factor. However, few researchers have explored this issue. According to the literature, it can be expected that students' attitudes will be affected when using the Internet and IT to conduct design learning projects. The problems they face can be classified into technological and human problems.

There are still no explicit models or frameworks for applying the Internet and IT to design education. Beyond creating and testing new models or frameworks, it is important to understand the attitudes and problems of the participating students and to obtain more information to assist in applying the Internet and IT to design education.

Methods

This study is part of a research project to explore the feasibility of adopting online design learning environments (ODLE) in design education. The action research approach (Brandt 2004; Swann 2001) was applied in this study. Both qualitative and quantitative research methods were used to study the development of, the influences on, and the problems faced in using the ODLE.

Extracting the influences of the Internet and IT on design education is a complex problem. Jones et al. (2000) claimed that using experimental methods to evaluate learning technologies is often considered inappropriate because of the difficulty of controlling variables that may affect outcomes. Scanlon et al. (2000) also point out that in a natural context, where the technology may be only one part of a course, other evaluation methods will also lead to difficulties in attributing learning outcomes to use of a specific technology. Gunn (1997) points out that the rigid nature of experimental design can have a negative effect on research.

Dyson and Campello (2003) have shown that learning is generally assessed through outcomes, but perceptions may in addition be informative. A range of variables can be measured by asking learners about their perceptions. Attitudes can sometimes be separated out from perceptions, but essentially both are measured by asking for an opinion or judgment; it is the focus of the question that differs. This focus may be satisfaction, estimates of how much has been learned, or the perceived usefulness of tools.

The factors and dimensions involved in learning are too many to be investigated or discussed. It would be difficult to describe the whole spectrum of influences on learning of using the Internet to mediate a design course. This paper therefore focuses only on the learner's perceptions to provide information for design educators who are interested in introducing the Internet into design courses.

Research questions

The purpose of this study is to understand students' attitudes toward and perceptions of using the Internet to mediate design studio courses, with particular attention to the following:

1. The influence of using the Internet to mediate a design studio course;
2. The students' attitudes toward using the Internet to assist in design education; and
3. The perceptions and experiences of the students in the Internet-mediated design studio.

Online design learning environment and experimental course

This study used CoCreaThink Design (CCTD), an ODLE developed by Chen and You (2003), in actual design studio courses, both in Chang Gung University (CGU) and in the National Yunlin University of Science and Technology (NYUST), to assist in design learning and teaching.

In these two universities, the industrial design curricula generally consist of three different subject areas: engineering, business, and art. In addition, courses in these subject areas can be further classified into three specific domains: professional knowledge, technical skills, and the core design studio. As for teaching methods, the main pedagogy in the professional knowledge courses is lectures, the technical skill courses emphasize demonstration and practice, and the design studio emphasizes design case projects of various degrees of complexity.

Online design learning environment: CoCreaThink Design

CoCreaThink Design is a platform for using the Internet to mediate design courses. It provides various functions to assist in learning and teaching. CCTD (<http://thinkdesign.cgu.edu.tw>) consists of three levels: Community, Classroom, and Studio. Figure 1 shows the main objectives, functions, types of interaction, and media used in each level. Details of each level are described below. A screen shot of the CCTD platform is shown in Fig. 2.

The first level, *Community*, provides site users with an open space to exchange opinions about design, to discuss design issues, and to share and exchange design information and experience. The objectives of this level are to improve the presentation skills, communication abilities, and social interaction of learners through the use of open discussions within the community, as well as to exchange design experiences. This layer provides a variety of design information and a method for discussing design concepts in an asynchronous way. The functions include not only design news, design articles, a design forum, and design resource links, but also a specific community established by users to discuss special themes within a particular group.

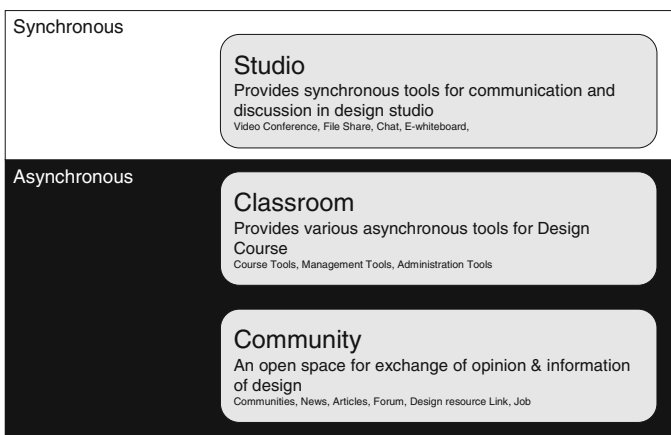


Fig. 1 Structure of the “CoCreaThink Design” online learning platform



Fig. 2 Screen shot of “CoCreaThink Design” (Community/Classroom/Studio)

The second level, *Classroom*, is the primary channel for learning. Several tools are provided to support design learning and course management at this level. The individual instructor is allowed to open his/her own course and to manage the enrolled students. This level provides an asynchronous learning environment which is suitable for the fundamental and technique-based courses. Because there are no limitations on file format and size, instructors can upload course material and download assignments submitted by the students, and vice versa. The students can therefore share, submit, and exchange materials related to the course without restriction. The main functions of this level can be divided into student and teacher modes. The student mode serves mainly to receive information and materials related to the course and to conduct general course activities such as uploading assignments and group announcements and sharing information such as course discussions and notes. The main functions of the teacher mode are related to the management of the course and its students, including the maintenance and publishing of teaching materials, delivery of course announcements, student grouping and management, and the evaluation of assignments and course discussions.

The third level, *Studio*, provides real-time interactive tools for communication and discussion of design studio activities. To provide a more convenient operational interface, NetMeeting modules provided by Microsoft, including a chat room, video conferencing, file exchange, and an electronic white board, have been integrated into this environment, enabling learners to perform design collaboration at a distance. Design activities and discussions are recorded in the database for later review and research purposes. The number of design studio classes is not limited; teachers can set up studios according to the needs of courses or projects to provide different groups for discussions.

This research applied the CoCreaThink Design platform to mediate the design studio course. This platform not only offers functions to help design learning and teaching, but also encourages students to share design information and to discuss design concepts with other members within this platform.

Experimental course

Third-year undergraduate students enrolled in design classes at two Taiwanese universities, Chang Gung University (CGU) and National Yunlin University of Science and Technology (NYUST), participated in this study. The students participated in the course at their own respective schools. Nevertheless, the courses had the same title, “Product Design.” Product design was the core course of the undergraduate industrial design education program in both cases. It was a one-year course divided into two semesters.

The course aims to cultivate the following abilities in students: (1) professional attitude, (2) design practice techniques and skills, and (3) application of design methods and theories. Studio (project-based) pedagogy was adopted, in which students learn through the processes of design research, ideation, simulation, and presentation to develop their own way of design, as well as learning how to define a problem, create ideas, and select the solution for the problem. Finally, through multimedia presentations, prototype making and display, and reports, students learn to present their learning outcomes.

A total of five design projects, including two inter-university collaborative design projects, were carried out during the one-year course using the CCTD as a mediator to assist learning and teaching. This course was based on the blended learning approach (Abrams and Haefner 2002; Bender and Vredevoegd 2006) which combines personal interaction in live class sessions with online education for greater flexibility. In addition to the traditional face-to-face interaction in a studio, the teachers also used the CCTD to announce course information and to hand out class notes; the students could use it to submit assignment files and to share and exchange design concepts and ideas. The CCTD also provided a variety of tools for communication, including an asynchronous discussion forum and a synchronous chat room and video conference facility; students and teachers could use these for various design activities.

Data collection and analysis

Both questionnaire and focus group interview methods were used to collect the data. First, a questionnaire was administered at the end of the experimental course to collect the students' subjective responses. The content of the questionnaire included the influence of using the ODLE for the design studio, the need for and satisfaction with the functions provided by the CCTD platform, and the students' attitudes towards the Internet-mediated design studio. All participants returned the questionnaire, 25 from CGU and 36 from NYUST.

To obtain a better understanding of the feelings of the students and the problems that the students faced, ten volunteers from CGU and NYUST (five from each university) participated in focus group interviews. The interviews were conducted separately at CGU and at NYUST and moderated by one of the authors. Each interview took one hour and was recorded by digital video recorder. The results were transcribed into text form for further analysis.

Results

Both the questionnaires and the focus group interviews were intended to collect the students' subjective evaluation of their attitudes and opinions about using the Internet to mediate a design studio course. The results of this exercise are described below.

Influences of the Internet-mediated design studio course

The influences of using the Internet to mediate a design studio were identified from the students' points of view. The questionnaire was designed according to the framework for development of an online design learning environment proposed by Chen and You (2003). In this framework, there were four dimensions: Course, Internet, Learner, and Instructor, each with four separate factors. The "Instructor" and "Student" are the main user of the

ODLE, the “Course” contains the main content for transfer between instructor and student, and the “Internet” provides the main channel for linking the components to the ODLE. A seven-level Likert scale was used to rate the responses; the range was from -3 (strongly negative influence) to $+3$ (strongly positive influence), with 0 representing no influence. For each question, the student circled the rating corresponding to his or her subjective experience. The results are shown in Fig. 3 and Table 1. The box plots in Fig. 3, a pictorial representation of the data distribution, portray the influence levels for respondents in 16 factors. The left-hand and right-hand boundaries of the box indicate respectively the lower and upper quartiles of the data distribution. The box length is the distance between the 25th percentile and the 75th percentile, meaning that the box contains the middle 50 percent of the data values. The thick vertical line inside the box identifies the median. If a median is coincident with the 25th (or 75th) percentile value, it means that the distribution has a positive (negative) skew. The larger the box, the greater is the spread of the observations. The lines extending from each box (called whiskers) represent the distance to the smallest and the largest observations that are less than one quartile range from the box. Outliers that lie between 1.0 and 1.5 quartiles away from the box are marked with \circ with respondent code, and further away outliers are marked with $*$. Table 1 shows the number of subjects and the mean and standard deviation (SD) of each factor. These results indicate that students felt that using the Internet to mediate the design studio influenced learning and teaching. For most items, the influences were positive, but certain limitations of the Internet had a slightly negative influence on both learning and teaching.

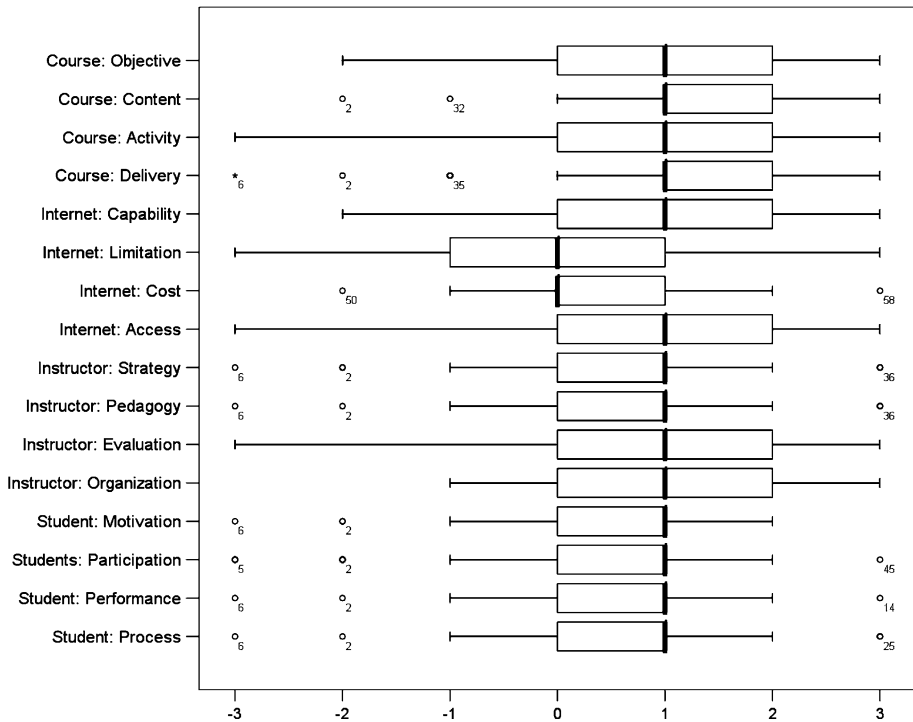


Fig. 3 Box plots of the influences of using the Internet to mediate a design studio course

Table 1 Results of the investigation into influences of using the Internet to mediate a design studio course

Dimension	Factors	<i>N</i>	Mean	SD
Course	Objective	61	0.93	0.98
	Content	61	1.05	0.86
	Activity	60	0.87	1.16
	Delivery	60	1.25	1.28
Student	Motivation	61	0.38	1.07
	Participation	60	0.37	1.38
	Performance	61	0.61	1.07
	Process	61	0.77	1.07
Instructor	Strategy	61	0.62	1.21
	Pedagogy	61	0.72	1.13
	Evaluation	61	0.61	1.31
	Organization	61	0.95	0.97
Internet (Technology)	Capability	61	0.90	1.21
	Limitation	61	-0.11	1.27
	Cost	61	0.48	0.89
	Access	61	0.51	1.43

Note: Rating response scale: -3 (strongly negative influence) to +3 (strongly positive influence)

Course

The “Course” contains the main content for transfer between instructor and student. Many factors need to be considered in the “course” component. The key factors are the objectives, content materials, course activities, and delivery method. In summary, most of the subjects thought that the ODLE had a positive influence on design studio learning and teaching, especially in course delivery (mean = 1.25, SD = 1.28) and content (mean = 1.05, SD = 0.86).

Internet (Technology)

The Internet provides the main channel for linking the components to the ODLE. It provides the protocol and the interface for running online design learning environments. Its capabilities, limitations, cost, and access method will influence the design and use of the ODLE. With regard to the influence of the Internet, the factors investigated included the functions that the Internet could offer (capability), limitations, cost, and access to the Internet to assist in design studio learning and teaching. The investigation found that the restrictions imposed by the Internet had a negative influence on the course (mean = -0.11, SD = 1.27). On the other hand, the functions that the Internet could offer (mean = 0.90, SD = 1.21) and the free and easy link to the Internet on-campus (mean = 0.51, SD = 1.43) were helpful in teaching the design studio course at lower cost (mean = 0.48, SD = 0.89).

Instructor

The “Instructor” is one of the main users of the ODLE. Strategies, pedagogies, evaluations, and organization of the students and course are key factors that the instructor should take into account when teaching a course. The students also expressed their opinions of the

influence of using ODLE on the instructor. The results showed that students mostly thought that using the Internet to assist in the design studio course had a positive influence on the course organization (mean = 0.95, SD = 0.97), the pedagogy of the instructor (mean = 0.72, SD = 1.13), teaching strategies (0.62, 1.21), and course evaluation (mean = 0.61, SD = 1.31).

Students

The “Student” is the other main user of the ODLE. In e-learning studies, the student has always been considered to be the center of the study system. Here the investigation into the influence on students of using an ODLE focused on students’ motivation, participation, performance, and learning process. Most students thought that the use of the Internet to assist in design studio learning had positive influences, such as improving the motivation to study (mean = 0.38, SD = 1.07), increasing participation (mean = 0.37, SD = 1.38), providing better design performance (mean = 0.61, SD = 1.07), and improving the learning process (mean = 0.77, SD = 1.07).

The results of the investigation showed that the influence of using the Internet to mediate a design studio course was generally positive, but that certain limitations of the Internet exerted a negative influence. As a guide to future use of the Internet, what are the benefits of using the Internet in a design studio course? The results of the focus group interviews could provide some indication of answers.

Attitudes

The results regarding the use of the Internet to mediate design courses are shown in Fig. 4 and Table 2. Because of the popularity of the Internet, most students had experience with obtaining support for daily life and learning activities through the Internet. They thought that using the Internet to mediate a design course was helpful to design learning, especially in the study of design knowledge (mean = 1.67, SD = 0.89), design data collection (mean = 1.49, SD = 1.10), assignment and report submission (mean = 1.37, SD = 1.24), sharing and exchange of design information and concepts (mean = 1.31, SD = 0.94), and receiving course announcements (mean = 1.31, SD = 1.10). Most of the subjects expressed acceptance of using the Internet to support design education.

Although the results demonstrated significantly high satisfaction with using the Internet to mediate a design course, the requirements for Internet capabilities, technology, and bandwidth caused a restriction which would become the most critical issue requiring resolution.

Perceptions and experiences of students

The perceptions and experiences of the Internet-mediated design studio course from the students’ point of view were collected from the focus group interviews after the experimental course. The contents of the focus group interviews were transcribed into text form for various kinds of coding and analysis. The contributions are divided into three sections: (1) benefits and advantages, (2) problems, and (3) suggestions.

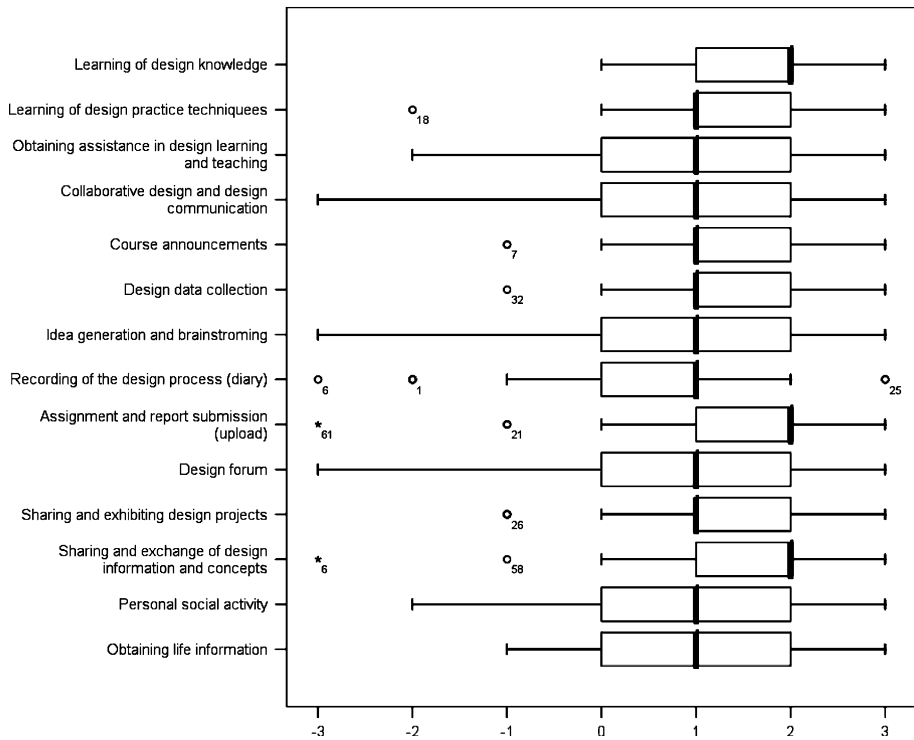


Fig. 4 Box plots of opinions of using the Internet to mediate a design studio course

Table 2 Opinions on using the Internet to mediate a design course

Item	Experience (%)	Helpfulness		Acceptance (%)
		Mean	SD	
Learning of design knowledge	91	1.67	0.89	94
Learning of design practice techniques	59	1.36	0.96	88
Obtaining assistance in design learning and teaching	74	1.09	0.99	94
Collaborative design and design communication	61	0.82	1.32	92
Course announcements	85	1.31	1.10	98
Design data collection	69	1.49	1.10	94
Recording of the design process (diary)	28	0.55	1.27	78
Idea generation and brainstorming	61	1.14	1.17	80
Assignment and report submission (upload)	91	1.37	1.24	90
Design forum	72	0.98	1.27	88
Sharing and exhibiting design projects	42	1.31	0.94	98
Sharing and exchange of design information and concepts	72	1.42	1.07	100
Personal social activity	44	0.93	1.27	84
Obtaining life information	74	1.16	1.05	90

Note: Scale of responses

Helpfulness: -3 (Useless) to +3 (Helpful)

Benefits and advantages

There were many perceived benefits and advantages of using the Internet in a design studio course:

- **Interaction and communication.** The use of Internet-mediated design courses increased the interaction between students and teachers. It also provided increased opportunities to interact with people outside the classroom. In the Internet-mediated design studio course, students could contact people outside the class, for example, peers, designers, or experts in different fields, and share or exchange concepts and design ideas with them. The CCTD is convenient for this purpose because it offers users a space for sharing and exchanging their design concepts and experiences.
- **Resource materials.** Abundant information on the Internet includes various kinds of materials required for design courses and projects. Easy linking and searching functions on the Internet were a very convenient and fast way to find various kinds of materials needed for these purposes.
- **Overcoming the restrictions of time and space.** Through the Internet, students could perform learning activities anytime and anywhere. Both synchronous and asynchronous interactive methods on the Internet remove restrictions of time and space, enabling everyone to share various kinds of information and concepts whenever and wherever possible.
- **Knowledge management.** Information and materials from the Internet and materials shared in the course could be stored on websites for convenient reuse at any time. All the materials were in digital format, easy to share, to exchange, and to manage using digital tools.
- **Other.** Being a new learning experience for participants, the course also provided new challenges for students to learn new skills and tools in the domains of interactive learning and Internet technology.

Problems

Although the students believed that using the Internet to mediate a design course offered many benefits, many problems were still encountered. The problems experienced by students could be classified into those related to technology, human factors, and the system itself.

- **Technology.** Technology problems had two major aspects. The first aspect involved the Internet infrastructure, including bandwidth and stability. The other involved the cost and operating difficulty of the new equipment, for instance, the need for students to buy webcams and microphones and learn their setup and operation to participate in videoconferencing.
- **Human factors.** Human-related problems include people's motivation, knowledge, and skill with using the computer and the Internet, as well as various kinds of habits, including how they use the technological tools and when they prefer to access the ODLE.
- **System.** The system aspect included some problems related to the functions, structure, and human interface of the course websites. For example, some functions were less easy to use and some functions were not efficient enough. In the interface design, the layout and the icon design needed to be improved.

The students' responses revealed many benefits for design learning in an Internet-mediated design studio course, but also some problems that need to be overcome.

Suggestions

Besides discussing relevant problems, interviewees also proposed some suggestions for improvement:

- System and interface. Most of the interviewees suggested that the interface design of the CCTD could have more graphics to increase user interest, and that the functions and the sequence of operations could be simplified.
- Increase the motivation to use the system. To improve students' motivation, interviewees proposed various ideas, such as providing a personal web space along with the course, providing a ranking system, and offering more learning materials and information, such as where to buy design materials and where to obtain assistance in model building.
- Consider the users' habits. Interviewees suggested that recognizing the wide variability of personal-use habits, giving users some time to practice and to adapt, and offering more flexible, customized environments in the system, would make the website more acceptable to users.

Discussion and conclusions

The results of the current investigation have shown that using the Internet to mediate design studio teaching had an influence on students' learning and on course delivery. The students also believed that it influenced teaching style. Some issues are discussed further below on the basis of the results of the investigation and the authors' observations and experiences in participating in the experimental course.

Selection and development of the online design learning environment

The Internet and IT offer great potential for design education, but realizing this potential will require good planning, resources, and cooperation (Kvan 2001b; Yee 2001). Broadfoot and Bennett (2003) pointed out that effective studio teaching, whether in the traditional face-to-face studio or in an Internet- and IT-mediated VDS, should be based on design content and reflection on design. Otherwise, a VDS using the Internet and IT-based tools would present an obstacle to design learning (Forger and Russell 1999).

An online design learning environment (ODLE) is an essential element when using Internet and IT to mediate design studio teaching. Because of the unique nature of design education, the selection and development of an ODLE should consider the particular needs of design education, including its nonlinear learning pattern (because design cannot be regularized as a sequential process of learning patterns (Chang and Huang 2002)), one-on-one dialogue in a collaborative context (Broadfoot and Bennett 2003), and use of multi-media and visualization (Chastain and Elliott 2000).

The main problems encountered when implementing an Internet-mediated design studio include both technological and human issues. The technological problems will change

depending on the evolution of technology. New technology and tools continuously provide more powerful and more reliable functions to solve the problems and remove the restrictions that earlier VDS systems faced because of immature hardware and technology. In evaluating such systems, the cost, convenience, and ease and effectiveness of operation of the new technology and tools should be considered, and their performance should be tested and verified. The human problems are different from the technological problems. Although some of the human problems are a reflection of the new technology and tools, they must be solved with reference to human considerations. Besides the human and technological problems, the character of design education is another question that needs to be considered. Although design tools and methods have been affected by the advent of the Internet and IT, the nature of design has not changed. Under the influence of new technology and abundant information, many students use inappropriate information without thinking and rely excessively on the form-making function provided by new digital tools, creating many novel but unreasonable designs. This experience is worthy of consideration by design educators.

Influences of using the Internet to mediate design studio learning and teaching

Although the Internet is now being widely used in design learning and teaching, the influence of its use has not yet been demonstrated (McCormick 2004). In this study, the students thought that using the Internet to mediate design studio learning had positive influences on course objectives, content, activities, and delivery methods, on instructors' pedagogies, teaching strategies, students' evaluations, and course organization, and on the learning motivation, course participation, performance, and learning process of students. According to experience and observation in the experimental course, there is indeed some difference between the traditional and virtual design studios. As for the course, the objectives of the studio course include not only teaching students the basic knowledge and techniques of design, but also training students to master the new design tools and to adapt to the new environment. The course content becomes richer because of the abundance of information and easy linkage to data through the Internet. Based on the convenience of IT, the course activities can extend beyond the classroom, unlimited by time and space. For the instructor, the multitude of design resources and the convenience of the Internet change teaching methods. Instructors can easily search and find many design cases and resources to share and discuss with students. Informal critiques among classmates happen more frequently during and after the class through the Internet. The evaluation of students has also extended to activities beyond the classroom, especially to participation and performance in activities conducted on the Internet. For students, this type of learning also changes their learning motivation and behavior. For example, some students have become more active and more immersed in the online course.

Using an Internet-mediated design studio influences not only the course delivery, the teaching of the instructor, and students' learning, but also the administration and setting of the design studio and the social interactions that occur. For example, drawing using digital tools requires digital equipment; therefore, computers and liquid crystal display (LCD) projectors have become basic equipment in the studio. The interaction and the role of students and instructors also changed when communication over the Internet become common. Some students who are quiet in traditional studios might become active in an Internet-mediated design studio, and vice versa. These changes have also been found in other relevant research. McCormick (2004) believed that the application of information

communication technology required changes in the arrangement of teaching and learning. In studies of the pedagogy of the virtual design studio, Kvan (2001a) also mentioned that the environmental setting and the relationship between students and instructors would be changed. Yee (2001) pointed out that social relationships were different in traditional and in virtual design studios, based on observation of ten virtual design studio projects. The new studios involve multidisciplinary design participants from separate and distant physical and social environments that are electronically connected for sharing design ideas, creating a common understanding of design practices, and co-constructing design objects. With this use of technology, changes occur in the studio's participants and relationships, design content and processes, and events and organization. Yee argued that the changes to the studio could create an enriched environment for design learning.

Apart from the positive influences mentioned above, there are also some negative influences. For example, abundant and convenient material on the Internet might induce students to access too much material and perhaps to spend too much time without being able to make appropriate decisions. The instability of the Internet could also cause information to be transmitted intermittently, which would influence design communication. Students might rely excessively on digital tools, spending most of their time and energy with them, and therefore would not practice their design skills and would not discover innovative solutions for design problems.

Preparation and adjustment of students and instructors

From the results of focus group interviews and observation of the experimental courses, it was apparent that the level of participation by some students was low. Upon further analysis, the reason could be divided into two parts, one related to the level of knowledge and skill in using the relevant equipment and technology, the other related to psychological factors. With regard to equipment and relevant technology, some students were novices in the use of the Internet and digital tools, so they felt that the new approach was inconvenient and not as easy as the traditional method. These problems might occur when they used new technology and new tools. As for psychological factors, although students usually participated in BBS and Internet community activities, they saw formal online course activities as a source of pressure. They were afraid that their grade would be affected by any inappropriate message content. On the other hand, the VDS provides an opportunity to those students who prefer not to talk or to express their opinions in a traditional studio.

Instructors also experienced pressure to use the new tools for teaching, especially instructors who were not experienced with the VDS. They needed to spend more time to learn the new technology and knowledge, as their students did. When using IT and the Internet to mediate the design studio, the instructors need to spend more time to prepare lecture material and to communicate with students to help their learning. In studio, the instructors always want to see students express the concepts and opinions of their design, to learn presentation skills, and to stimulate creative thinking. However, in the VDS, the large quantity of material to be covered and the disorganized content frequently posted by students caused the instructors to spend much time dealing with misunderstandings.

According to the previous discussion, preparation and adjustment of the students and instructors are important when using the Internet to mediate a design studio or to conduct a virtual design studio. The preparation includes the configuration of the hardware, the learning of the knowledge and operational skills needed to use the software, and the planning and adjustment of the psychological aspects related to new technology. An

appropriate preparation and adjustment period before the start of the class could help the progress of the Internet-mediated design studio.

Suggestions for an Internet-mediated design studio

Computers and the Internet are necessary tools for daily life and learning of students today. For design education, because of the uniqueness of design knowledge, when introducing the computer and the Internet to assist or to conduct the design studio course, the special needs of design education must be considered. The following are suggestions arising from actual experience and observation of using IT and the Internet to mediate a design studio. The content includes how to choose or develop the online design learning environment and how to introduce online-assisted teaching into design studio courses.

- Outstanding network infrastructure and technical support. Judging from actual teaching experience, the network infrastructure has a very great influence on the teaching process. If the network infrastructure is not good enough, many problems result. For example, the design process always uses large quantities of multimedia and high-quality images to present concepts and ideas. Unstable network conditions will cause breakdowns in communication, or Internet traffic jams will hinder uploading or sharing the large amounts of content and information required by the design process. These problems usually influence the design studio and the processes of after-class discussion, in particular causing instructors and students to spend large amounts of time solving technical problems rather than design problems. Therefore, good technical support is very important. If technical problems cannot be solved immediately, they can have a serious negative influence on the design progress.
- Preparation and adjustment of instructors and students. When confronted with new technology and teaching methods, most instructors and students need time to adapt and to adjust. Concentrating too much on Internet and technological problems might affect the progress of a design project. In addition, before initiating this kind of learning/teaching method, teachers should receive relevant training on how to teach students about the knowledge and equipment related to the Internet and information technology. The instructors must also communicate with students beforehand, so that they can understand how to proceed and prepare themselves psychologically. This would be useful to avoid the influence of increasing workload due to digital or network working environments on students' learning motivation and willingness to participate.
- Instructor participation and interaction. The teaching process in the design studio emphasizes informal one-on-one critique. Using an Internet system to assist the design studio courses might increase the interaction between instructors and students or among students. However, it might also increase instructors' workload and thus might cause the instructors to feel harassed. Many educators were not as willing to participate fully in Internet activities as the students were. In this case, the value of using the Internet would be lost and the students might even develop negative attitudes, with the end result that they would not be able to continue the Internet courses. As a result, it is important that educators should spend time interacting with their students on the Internet to understand their situation and any problems that arise and to give suggestions or feedback.
- Adjustment and learning process. The attitude of educators and students usually influences teaching and the achievement of learning, in traditional as well as Internet

courses. Because the Internet offers a large amount of material compared to traditional learning methods, it could make multiple learning methods available to let students learn according to their own learning style. Therefore, educators should extend education processes and make the best use of the advantages of the Internet, cooperate with students' characteristics and demands, adjust their teaching methods, and offer a more flexible and pluralistic online learning environment for students.

- Myths surrounding the Internet and the computer. The Internet and the computer are just tools for design learning. Many students believe certain myths about technology. For example, some students use a large number of computer-aided drawing tools to complete their design projects, but do not involve their own thought process in creating the product. Students may believe similar myths about the Internet. Some students think that the abundance of information on the Internet is a sufficient basis for design. Therefore, in their design process, they may obtain information only from the Internet which is not peer-reviewed and is not sufficiently reliable. Students may cite a large number of sources without thinking about this point. As for design, beside basic guidelines and reference materials, contact with real experiences and products and the user's lifestyle is also important. When using the Internet to assist in design teaching, the instructors should be mindful of and pay attention to students' learning processes, guiding and correcting them as appropriate. Moreover, some students might become excessively immersed in the Internet or appear there with different personalities carrying out harassment and other illegal acts which they would not dare to perform in person. These are important issues which all educators need to consider.
- The risks. Although the Internet and IT have great potential in design education, there are still risks in their application. Van Eijl and Pilot (2003) have pointed out that sole reliance on virtual instruction poses a serious risk because "live instruction has to build upon the virtual part and vice versa." The design curriculum generally consists of different subject areas with different characteristics. It should always be considered whether or not this approach is suitable for a particular course.
- The degree of usage of the Internet and IT. Bender and Vredevoogd (2006) remind us that to change the culture of the existing studio environment, digital media must become a transparent tool for design inquiry. Instructors should give serious thought to the complex pedagogical issues underlying new methods of teaching and learning before implementing them in the curriculum.

Concluding remarks

The purpose of this paper is to investigate student attitudes toward and perceptions of using the Internet and IT to mediate a design studio course and to propose guidelines and suggestions for developing Internet-mediated design studio courses. To understand the nature and features of design education and the potential and problems of applying the Internet and IT to design education, the relevant literature was reviewed. Student responses and perceptions were collected through the experimental design studio course mediated with the Internet and IT. The results show that the students expressed acceptance of the approach and thought it had a positive influence on design studio teaching and learning. On the other hand, they also encountered technological and human problems that have been documented in related literature.

Although the results were positive in this study, some aspects remain to be clarified. The Internet and IT have many advantages and great potential in design education, but they are

not without risks. Some further questions need to be answered before applying these technologies. For example, is a particular course suitable for using the Internet and IT to conduct or mediate teaching and learning? What should be the role and function of the Internet and IT in the course? What kind of influence or risk may the Internet and IT impose on design education?

According to the experience of design teaching and the experimental course, the authors agree with the view, as proposed in the literature, that the Internet and IT are tools for design and design education. They may change the methods and environment of design, but not the nature of design and design education. They can help to overcome some restrictions with an appropriate approach to design teaching and learning and only with due consideration of the risks that may accompany their use.

Assessing the influences of the Internet and IT is a complicated issue. It is hard to present a holistic view and draw definitive conclusions. This paper provides one piece of the puzzle which can help to understand students' perceptions of using the Internet and IT in design education. Although the results of this study show a positive response, further research and evidence are needed to provide proof. Furthermore, the risks of applying the Internet and IT to design education should always be borne in mind.

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